An interesting aspect of the field trip was that the air temperature at 11:00 a.m. was 85 degrees F but a thermometer on the bog surface read over 90 degrees and another only 6 inches under the surface showed only 63 degrees. The sphagnum moss makes an excellent heat insulator. The roots of many of the plants including Sarracenia are protected from extremes of temperature and kept cool year around. The water trapped in the moss absorbs heat during the summer and then releases it during the winter. This insulator/latent heat effect helps explain how northern plants can survive so far south. The sphagnum itself, is saturated with water, alive and healthy.

The carnivorous plants are not found on the shores of the lake since conditions for survival do not exist there. Only on the island can they survive and the survival of the island is in doubt. Wave action and the alkaline water of the lake are destroying it. It may last another 150 years, but who really knows? To help preserve it the island is now a Registered Landmark and Nature Preserve. Today, all that can be done is to preserve the island as well as possible. The island can be visited during the annual open house or a permit can be obtained from the O.D.N.R., Division of Natural Areas and Preserves, Fountain Square, Bldg. F, Columbus, Ohio 43224.

See it while it's still with us, this floating isle of carnivorous plants.

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THE MYSTERY OF THE NEPENTHES OR JUST HOW DID THEY GET THERE?

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Species of the genus Nepenthaceae are among the most beautiful of the carnivorous plants. The multi-colored and multi-shaped pitchers are truly wonders to behold. Along with the beauty of *Nepenthes* comes a mystery. How did these plants get where they are today or what method of distribution accounts for their present locations?

Nepenthes are found on the island of Madagascar, the Seychelles Islands, Sri Lanka, the Assam region of India, Thailand, Laos, Cambodia, Vietnam, Malaysia, New Guinea, the Philippines, the northern tip of Australia and the island of New Caledonia. The distance from the western limit, Madagascar, to the eastern limit, New Caledonia, is about 12,000 miles with vast areas of water in between. How could they travel so far? New Guinea and New Caledonia both support the same *Nepenthes* species, *N. vieillardii,* yet are 1200 miles apart with only a few islands and ocean between them. No *Nepenthes* are found between these two islands. Why? Madagascar is only 200 miles from Africa yet no *Nepenthes* have ever been found in Africa. Why? The Seychelles are surrounded by the Indian Ocean and *N. distillatoria* lives on its highlands; with *Nepenthes* to the east, Assam, and west, Thailand and in Malaysia, Burma has none. Again, why is this so?

Mysteries of nature are bound together by seemingly unrelated events or processes that are themselves mysteries. The mystery of the *Nepenthes* is a classic example. In the past twenty-five years earth science has undergone a revolution in theory and thought about the

structure of the earth and the forces that act on it. These forces of change effect not only the rocks and oceans of the earth but also every living thing that ever was or that ever will be. The major force or cause of change is embodied in the concept of continental drift. This concept presents the continents as mobile "plants" afloat on top of a pool of molten plastic like rock called the upper mantle. The continents are not fixed on the earth's globe but rather move upon it and in so doing collide with one another forming larger super-continents, or split apart forming oceans. Some parts of continents will split off, drift awhile and collide with another.

This grand concept, also known as plate tectonics and continental drift, which explains so much about the earth, can also be used to explain the mystery of *Nepenthes'* distribution. As with any explanation, this concept's strength will lay in its ability to solve what seem to be unrelated facts. I believe that plate tectonics explains this phenomena.

As with most things under the sun this theory is not new. Using the pioneering work of Alfred Wegener in 1928, D.H. Danser first proposed that *Nepenthes* rode the continents. Wegener was probably the first to suggest the concept of continental drift and published his theories in 1924. Wegener believed that India was connected to Africa and Asia and split from Africa about 180 million years ago. Danser, therefore, believed that *Nepenthes* evolved in Asia on the Indian sub-continent and spread from there. In 1930 Du Toit revised Wegener's work by placing India with Africa so that India split from Africa and collided with Asia, thus forming the Himalaya Mountains 40 million years ago. Today's concepts, (with some modifications), follow the Du Toit revision.

It's time to give a quick review of what is now believed to have happened to the earth since the last super-continent, called Gondwanaland, broke up. Below is a chart of events and the approximate times involved. Time is expressed as MYA or Million Years Ago.

TIME	EVENT
140-160	Initial separation of South America and Africa from Madagascar, Antarctica, India and Australia
140	Madagascar, Seychelles Islands and India separate from Antarctica and Australia
120-135	Flowering plants, the Angiosperms, evolve. *Nepenthes* soon follow
100	India and Seychelles separate from Madagascar
80	East Australia Rise with New Caledonia, separate from Australia and begin to move to their present locations
50-60	India separates from the Seychelles Islands
40-50	Australia separates from Antarctica
40-45	India collides with Asia forming the Himalaya Mountains
10	Australia with southern New Guinea arrive at present location
1-3	Mount Kinabalu in Borneo is formed.

This is all well and good but what does it really have to do with *Nepenthes?* I hope to make this point a little clearer as I proceed but this time/event chart serves well as a guide as we go through 160 million years of earth history.

Nepenthes, as beautiful as they are, are a primitive group: by that I mean their reproduction and seed dispersal methods are not very advanced. Unlike the more advanced flowering plants, which are bisexual, *Nepenthes* are unisexual having male and female plants. Unisexuality insures a greater genetic diversity than bisexuality since self pollination cannot occur. Pollination in either case usually requires some third party agent like insects or wind to carry pollen from one plant to another. Bisexual plants have the possibility of self pollination thereby insuring a new generation. Unisexual plants do not have that option; thus, the unisexual *Nepenthes* must depend on male and female plants flowering at the same time and upon a pollinating agent to carry pollen from flower to flower. The *Nepenthes* flower can hardly be called attractive but other animals may find it so (beauty is in the eye. .).

Once pollination occurs and fruit is produced the next problem is getting the seeds dispersed. *Nepenthes* seeds are not aero-dynamically designed for long distance flight in the air nor light enough for forest winds to carry them far. Since most *Nepenthes* are mountain-forest plants with rather narrow vertical ranges, the odds of winds carrying a seed to a similar environment are not good. Water can carry seeds down hill but again the vertical range environment is the major survival factor. It appears that *Nepenthes* species in a particular environment are doomed to remain in that environment. *Nepenthes,* it can be said, are physically incapable of traveling far from home.

One can conclude from the above that *Nepenthes* did not effectively get where they are today by seed. The environment in which *Nepenthes* evolved acts as a trap. Only if *Nepenthes* had already evolved over 100 MYA and ridden on the continents with its environment could they have gotten so far today. Fair enough, but how did *Nepenthes* do it?

Referring to the Time/Event chart it can be seen that the flowering plants evolved, or at least their pollen was common enough to be preserved as fossils, about 135 MYA. *Nepenthes* would have had to evolve before India and the Seychelles drifted from Madagascar (100 MYA) or *Nepenthes* would not be found there. This, however, depends on where *Nepenthes* originally evolved. I believe that Madagascar was the original site but more about that later. So now we have a model to explain the presence of *Nepenthes* on Madagascar, the Seychelles Islands, Sri Lanka (which is geological part of and once connected to India) and Assam India.

How to explain the South-East Asian locations? Actually, there are two ways. The first one, proposed by Danser in 1928 and later S. Kurata in 1976, presents *Nepenthes* riding on India which collides with Asia about 40 MYA. From here *Nepenthes* spread slowly through Assam, into Burma, into Thailand, down the Malay Peninsula and so on to New Caledonia. Forty million years would be long enough for the trip so time is no problem. The water barriers in South-East Asia are no problem either since the seas are shallow and sea level has fluctuated quite a bit in the past forty million years. What are now seas were once dry-land bridges connecting islands and the mainland together. This ties things together but this theory still has its problems.

First, how did *N. vieillardii* get from New Guinea to New Caledonia? Geologically New Guinea and New Caledonia probably have never been closer than 1000 miles. A land bridge has not existed between the two for at least 80 million years. What few islands that exist between them are far apart and do not have any *Nepenthes* species growing on them. The next problem is trying to explain the absence of *Nepenthes* in the Burma area. One explanation is that *Nepenthes* once lived in Burma but are now extinct. Another is that they have not yet arrived.

I propose the following model. *Nepenthes* evolved around 120 MYA in the Madagascar area of Gondwandaland. This gives them enough time to spread into the Seychelles, Indian

and Sri Lankan areas. As noted above, these areas had already split from Australia, which at that time included part of New Guinea and New Caledonia with dry land between them. During this time several now-submerged marine plateaux were elevated between Australia and Madagascar so plants and animals could still migrate for several million years. If this is true, by 80 MYA *N. vieillardii* must have already evolved in order to exist in two widely separate locations. The ancestor or ancestors were probably low-land species similar to *N. mirabilis* from which other highland species evolved. So according to this model *Nepenthes* is already migrating across a large area including parts of Australia. By 80 MYA New Caledonia splits from Australia and starts its journey to the north-east carrying *N. vieillardii* with it. Australia and New Guinea arrive and cause the formation of Northern New Guinea.

The *Nepenthes* which survived the trip across the equator were probably mostly highland species since high mountain environments would not change as drastically as the lowlands. Most of Australia became desert, save along the coast. In the mountains of New Guinea *Nepenthes* would have survived and would start to migrate from island to island and finally to the Asian mainland. This would explain the lack of *Nepenthes* in Burma since it hasn't "arrived" yet.

It may well be that the truth lies somewhere between Danser's theory and my own but one thing is for certain: The evolution of *Nepenthes* is still going strong. A classic example is Mount Kinabalu in Borneo. The mountain is a slab of granite that forced its way through the Crocker Mountain range by the forces that moved the continents. In fact, it was the collision of the Australian plate with the Pacific plate that formed the mountains in the first place beginning 30 million years ago. More to the point is that Mount Kinabalu is only a million years old. Since it has endemic species *(N. burbidgeae, edwardsiana* and *rajah)* it is safe to assume they are not as old as the mountain they live on. It's probably a good deal less since Kinabalu had an ice cap on its summit during the last glacial period 10-20 thousand years ago. The ice would have depressed the vertical ranges and environments of *Nepenthes* during that time and would have placed a great deal of evolutionary stress on the genus.

The preceding discussion is just a very brief overview of a very complex series of event which changed and is still changing the surface of the earth and its inhabitants. Plate tectonics and continental drift explain many of the mysteries of *Nepenthes* distribution and could be applied to other groups of carnivorous plants such as *Drosera.* In any case, I find it fascinating that a contemporary of the dinosaurs can be not only a source of pleasure, but also serve as a guide to a world forever lost in time.

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Want Ad

Tom Gibson (Dept. of Botany; 132 Birge Hall; University of Wisconsin; Madison WI 53706) (Wants pure yellow trap form-no red of *D. muscipula* and pure yellow flower form of *S. leucophylla* (no red in traps).