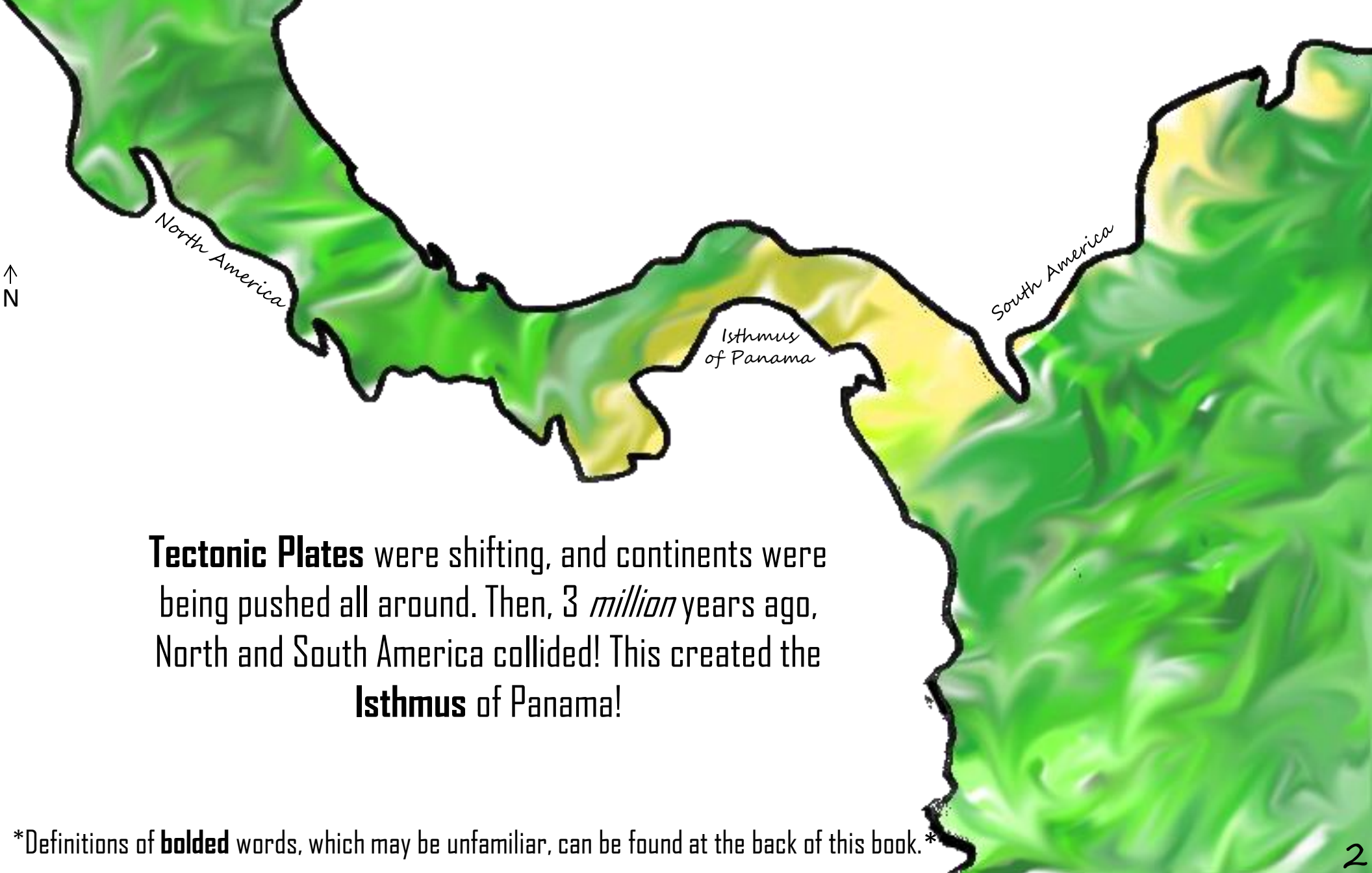

meet G.A.B.I.
The Great American Biotic Interchange

Three million years ago the planet looked very different from the one we call home today. There were different animals and plants, and they lived on a map that looked similar, but not quite the same, as the one we now know.

But, something big was about to happen that would make that world much more familiar to those of us around today!



Tectonic Plates were shifting, and continents were being pushed all around. Then, 3 *million* years ago, North and South America collided! This created the **Isthmus** of Panama!

*Definitions of **bolded** words, which may be unfamiliar, can be found at the back of this book.*

For many of the **flora** and **fauna** living in *either North or South America* or in the *seas* and *skies* around them, this meant there were about to be some BIG changes!




The new Isthmus of Panama acted like a bridge—allowing **terrestrial** creatures land by which they could finally hop, skip, walk, run, and crawl their way into new places. This land bridge also helped high flying birds make the trip to a new part of the world, giving them a place to rest their wings during the long journey! But for the many **marine** creatures living in the Atlantic and Pacific Oceans, this bridge was more like a *brick wall!* Instead of letting these water-loving creatures explore new places, it cut them off from much of what they used to call home.




This GREAT BIG CHANGE meant something different for animals and plants living on land, seas, and sky! Turn the page to find out how animals from each of these homes felt about G.A.B.I!

by land

Martha the mouse

Martha Mouse had been living in North America for a long time, and she liked it quite a bit. But, when she heard about the Isthmus of Panama opening up new real estate in South America, she couldn't help but get excited! Martha had a LOT of cousins, and she was looking for somewhere she could take her big, fat, gigantic, rodent family!

South America seemed like just the place: it was full of the **temperate** climates Martha liked and there weren't too many other animals living in those parts of the country. It was a perfect fit!

by land

Families of **mammals** from North and South America were excited to explore the other continent that the land bridge gave them access to!

Mammals like Martha Mouse, Stuart Saber-tooth the Cat, and Donald Deer were from North America, but decided to move their families south! Once they got down there, they loved it so much that their families grew and grew and grew. Along with their other buddies like Gerry Gomphothere and Stacy Squirrel their families grew SO LARGE they now make up half the **taxa** present in South America...talk about guests who overstayed their welcome!

Charles the deer

Stuart the saber-toothed cat

Martha the mouse

by land

Mammals from North America like Gerry the gomphothere and Stacy the squirrel loved to move south across the land bridge, much much more than any of their new friends in South America wanted to move north.

Gerry the gomphothere

There are many **theories** as to why North American mammals like Martha Mouse or Stuart Saber-Tooth were so successful on their trip south and were able to have their families grow so large in this new place! Some think that northern animals moved into **niches** that southern ones hadn't wanted for themselves. Others think that **carnivores** like Frankie the Stuart Saber-Tooth found too much new **prey** to pass up, and just had to stay and eat their fill. And yet others think that, because Northern animals had experienced interchanges before, they were more suited for success this time around!

Stacy the squirrel

Whatever the cause, it is clear that G.A.B.I. lead to many land mammals moving between the continents, with a much larger number of mammals moving from North to South than the other way around!

by sky

We might think that if Barry Blackbird can fly, he wouldn't care very much about a land bridge. If he wanted to take his trip from South to North America, why was he waiting around for the Isthmus of Panama?

But Barry the blackbird isn't a very good swimmer and he gets tired on long flights, so he needs a place to rest along the way. His favorite stop is a nice, dense forest where he can have all his favorite things. When the Isthmus of Panama formed, there was plenty of new forest to go around!

Barry had heard from his friend who had already left South America to visit North America that Barry would love it there! His friend, George Generalist, liked long trips, especially if there were ocean islands for rests along the way, and wasn't a picky eater like Barry so he was able to make the trip before the land bridge formed.

Unlike his terrestrial neighbors like Martha Mouse and Stacy Squirrel, Barry and his family had lived in South America their whole lives and wanted to travel north! The dominant pattern of transition for **avian** species during G.A.B.I. was from South to North!

Barry the blackbird

by sea

Unlike their neighbors on land and in the sky, those creatures living in the sea did not call the Isthmus of Panama a land bridge, but instead a land wall! Before 3 million years ago, the Pacific and Atlantic Oceans were connected in the Caribbean.

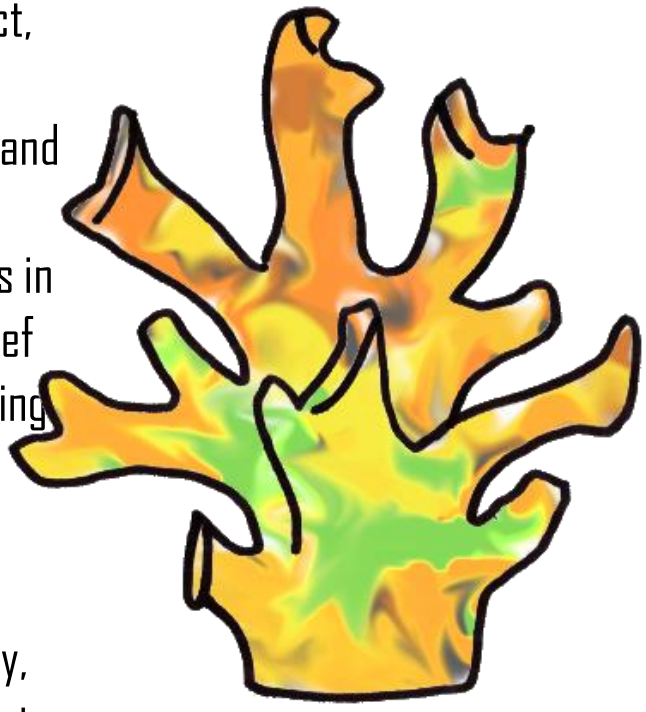
When the Isthmus formed, much of sea life was cut off from parts of their former habitat. Carl the Coral and Monica the Mollusk felt pretty worried about the effects the Isthmus of Panama was going to have on all their friends. Would they be able to survive when some of them were stuck on the other side of the land wall?

by sea

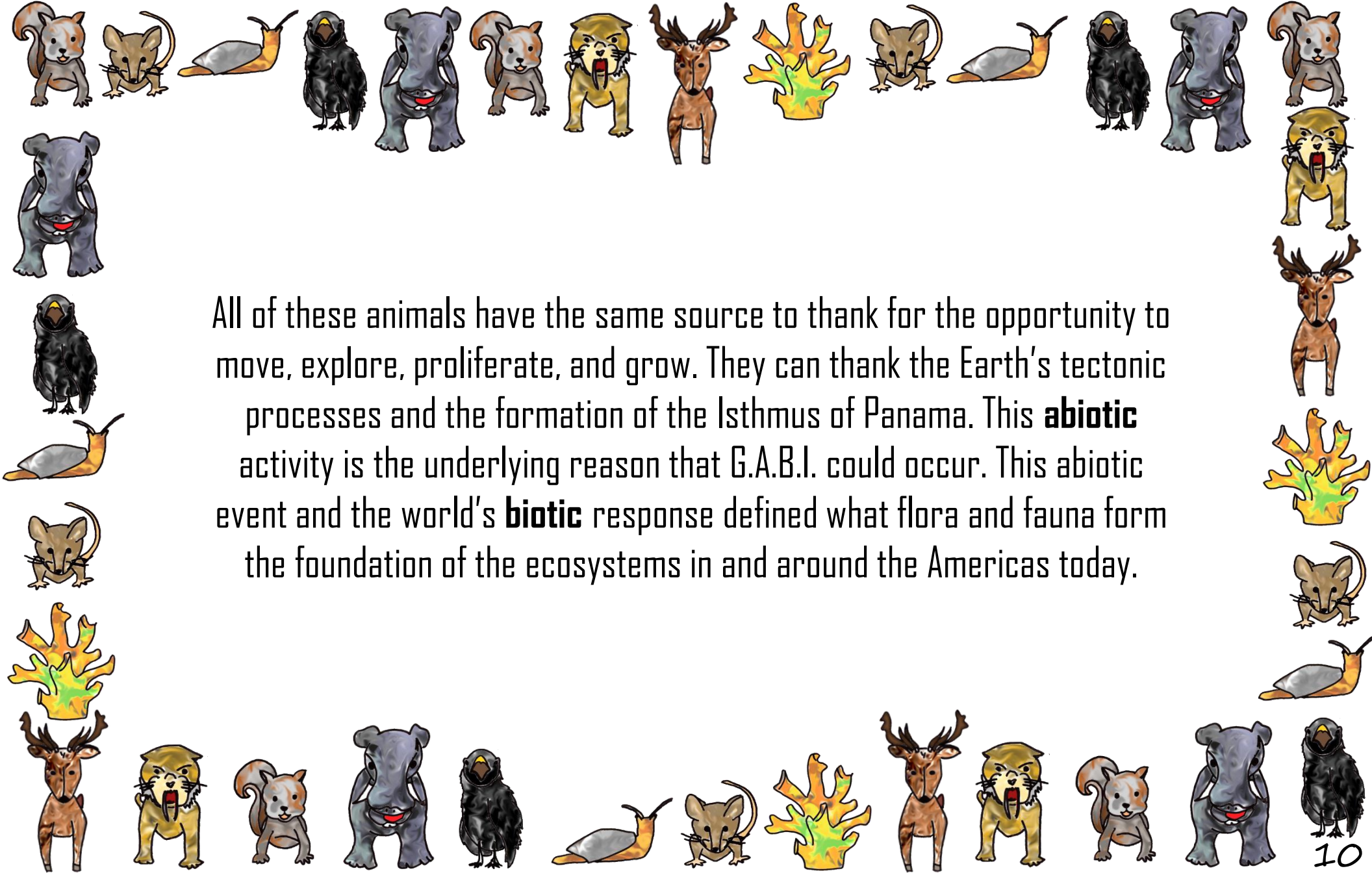
Even though they missed their friends, and their contributions to the **ecosystem,** Carl and Monica knew how to make the best of their new situations. In fact, Monica and her family of Mollusks found the new conditions in the Pacific to be very accommodating, and they **proliferated** throughout the region. Monica particularly loved the shallow sand and mud habitats in the Pacific! On the other side of wall, corals and reef and rock dwellers found their new home, recuperating from any losses due to the land bridge very successfully!

Monica the mollusk

Although their populations remain in isolation today, both Monica and Carl hope they can one day connect again and experience the interchange known to their terrestrial and avian neighbors when G.A.B.I. came along!



Carl the coral



All of these animals have the same source to thank for the opportunity to move, explore, proliferate, and grow. They can thank the Earth's tectonic processes and the formation of the Isthmus of Panama. This **abiotic** activity is the underlying reason that G.A.B.I. could occur. This abiotic event and the world's **biotic** response defined what flora and fauna form the foundation of the ecosystems in and around the Americas today.

DEFINITIONS

(2) Tectonic Plates The sub-layers of the Earth's crust which move and carry the surface features along with them. They are responsible for continental drift, earthquakes, mountain building, and more.
(2) Isthmus A narrow piece of land with water on either side which connects to larger pieces of land
(3) Flora Plants
(3) Fauna Animals
(3) Terrestrial Of the land
(3) Marine Of the sea or ocean
(4) Temperate (climate) Relatively moderate temperature and seasonality
(5) Families the taxonomic classification of organisms between genus and order
(5) Mammals endothermic vertebrates belonging to the class Mammalia (most often identified by a hairy body covering)
(5) Taxa any group in a biological classification into which related organisms are held
(6) Theories a conjecture or speculation; an expectation of what would happen barring unforeseen circumstances
(6) Niches the specific area where an organism inhabits
(6) Carnivores meat-eaters
(6) Prey an animal that is being hunted or consumed
(7) Avian of or relating to birds
(9)Ecosystem a system including all living organisms in an area and its physical environment
(9) Proliferated to produce successfully
(10) Abiotic not relating to life
(10) Biotic of or related to life

WANT MORE?

If the story of G.A.B.I. intrigued you, there are a variety of resources on the pages that follow! The author has included a list of the peer reviewed literature used to prepare this short book on the final page . In addition, immediately following this page, the author has provided a more in depth summary on the state of the literature used in this story. It might be useful for discussing the stories of Martha Mouse and Barry Blackbird with young readers with a greater knowledge of the science of G.A.B.I. It is meant to provide a useful summary before a reader dives into the literature themselves!

The Great American Biotic Interchange (GABI) was the result of the formation of the Isthmus of Panama connecting North and South America nearly 3 mya. Prior to this connection, This abiotic event created the catalyst for a series of biotic interactions that would come to define the ecosystem of the Americas. As a result, scientists have studied how different taxa responded to the abiotic event in their respective realms. Particular focus has been paid to land mammals due to the abundance of the record, but recent work has aimed to better understand the impact on sea creatures and birds (Jackson et al 1993, Vermeij 1993 and Weir 2009 respectively). Despite the different degrees of response clearly varies depending on the subject studied, it is clear that this abiotic event had a profound impact on the nature of its ecosystem.

When it came to land mammals, the narrative is dominated by the overwhelming success of North American taxa in South America. While there were a few South America groups which made their way north, such as armadillos, ground sloths, porcupines, and *Titanis,* a large terrestrial carnivorous bird, which successfully made the South-North transition, they were the exception not the rule (Marshall 1988). North American emigrants were extraordinarily successful and today ½ of the taxa present in S. America are of N. American origins (Marshall 1988). This was not just a result of increased migration, but rather prolonged success of N. American groups long after the biotas first met. In fact, Webb argues that the initial processes of interchange followed that which would be expected under equilibrium, with relatively equivalent numbers in either direction when source abundance is accounted for; however, he claims that the real success of the N. American taxa is reflected a million years later, which many were experiencing exponential proliferation rates in contrast with their struggling S. American counterparts (1991). Theories speculating the reasoning for this asymmetry abound. Some point to a biological advantage of N. American taxa—they were more fit in terms of competition, defense, and reproduction (Vermeij 1991). Some specifically point to the source of advanced mammalian predators coming as Northern invaders, stating that these predators would have been far superior to any prior experiences of S. American taxa and quickly took advantage of this fact (Webb 2006). Other scientists wonder if fitness of the population was a primary factor, but that the important difference came from the fact that N. American taxa had experienced and survived prior interchanges (Marshall 1988). Could this acquired genetic toughness have been enough to displace the long-isolated S. American taxa unfamiliar with outside invaders? Yet there still exists a question of the biological superiority of these invaders, and the possibility that they were just more suited for available niches in S. America than native populations may have been (Webb 1991). As more temperate climate regions emerged throughout S. America, N. American animals which were well adapted to these environments may have been quick to fill these niches (Webb 2006). Whatever the cause, it is clear that the mammalian terrestrial transition during the GABI was particularly North-South.

In the air, the interchange is less rigorously constrained by the emergence of the land bridge 3 mya. This is, for the seemingly too simple of a reason, because birds can fly. Weir, et al found that the land bridge completion did have a significant impact on the exchange rates of certain groups. Before the land bridge was completed, interchange was limited to those groups who could make the journey (2009) This fell to habitat generalists, who were not limited in where they could live or what they could eat. These groups would cross using mid-ocean islands as temporary habitat along the journey. When the land bridge was completed, it was populated by a forested environment. This environmental shift allowed tropical-forest specializing groups to disperse across continent as they had not been able to before. Unlike the mammals above, birds followed a primarily South-North dispersal pattern as they sought more densely forested habitats (Weir 2009).

The final region covered by the literature is that of the oceans. Prior to the formation of the land bridge, there existed a seaway allowing connections across the Caribbean. Given that the land bridge facilitated isolation in the marine realm, many scientists used to believe that extinction would follow this closure. However, this has not been consistent with the evidence found. Rather, scientists believe that different groups responded to the variety of habitats created by the Isthmus. The tropics themselves are considered favorable to speciation and scientists can always expect abundant diversity in the region (Vermeij 1993). Following a unique abiotic event like the one being discussed, it becomes clear that different clades will not respond uniformly to changes in the ecosystem. During the period of tectonic upheaval in the region, sea life responded in a variety of ways. Vermeij observed early separation in some groups, far before the land bridge reached the surface, Nearly 12.5 mya, he observed the impact of a shallow uplift on ocean turbidity and the resultant isolation of some species from the others. During the period of GABI, Vermeij concludes that large suspension feeders and molluscan clades succeeded and diversified throughout the Eastern Pacific, probably due to the shallow sand and mud habitats that characterized the seascape. In the W. Atlantic, he notes the success of reef-dwelling and rock-dwelling groups in their recuperation following the closure of the seaway.

In conclusion, it is clear that the formation of the Isthmus of Panama had a remarkable impact on the biotic responses in the ecosystems surrounding it. Though the responses may have varied, they all share a common link in their abiotic catalyst event.

Further Readings

Marshall, Larry. (1988) Land Mammals and the Great American Interchange. *American Scientist* 76: 379-388.
Vermeij, Geerat. (1991) When Biotas Meet: Understanding Biotic Interchange. Science 253.5024: 1099-1104.
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Weir, JT, et al. (2009) The Great American Biotic Interchange in Birds. *PNAS* 106.51: 21737-1742.


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