The Thrifty Genotype of Pacific Islanders and Amerindians: Differences in the Disorders Associated with Modernization

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2-27-03

Text Pages including references cited: 21
Number of graphs: 5
Number of Tables: 1

Introduction

Both Pacific Islander and Amerindian populations possess high rates of obesity, cardiovascular disease, and non-insulin dependent diabetes mellitus (type II diabetes, or NIDDM) (Weiss, et al.,1989, Bindon and Baker, 1997). This high prevalence of disorders is associated with the "thrifty gene." The thrifty gene allows those who possess it to store fat more efficiently. With modernization, however, comes a modernized diet, which has caused those who possess the once beneficial gene to be susceptible to these disorders and diseases. What does not seem to have been addressed in research, however, is why Amerindians possess one of the highest rates of gallbladder disease in the world (Everhart, et al., 2002), while Pacific Islanders, who also have the thrifty gene, show a much lower rate of the disease. A possible reason that Amerindians exhibit high rates of gallbladder disease and Pacific Islanders do not, is that Amerindians have what has been termed The New World Syndrome (Weiss , et al., 1989).

The purpose of this paper is to discuss one of the differences in the consequences of modernization in Amerindian and Pacific Islander populations, both of which possess the thrifty genotype. While Amerindians possess high rates of gall bladder disease, Pacific Islanders do not. Possible reasons for this difference will be discussed in this paper, including the possible link to the New World Syndrome.

The Thrifty Genotype

The thrifty genotype model was first proposed by Neel in 1962. While there is no direct genetic evidence for a thrifty gene, a logical conclusion to the scientific evidence that is available , is that the thrifty gene was an adaptation that allowed more efficient energy storage in the body. (There will be more discussion of the evidence for the thrifty gene later in this paper.)

The thrifty gene is present among Amerindians and Pacific Islanders. The thrifty gene appears to be an adaptation by natural selection in both populations. The adaptation was in response to an environment that did not consistently provide carbohydrates (Bindon and Baker, 1997). The gene allows those who posses it to store fat to be used during times of food shortage. This utilization of fat stores is beneficial because it prevents one from having to deplete the protein stores, as happens in starvation and semi-starvation (Frisancho, 1993). This extra fat store would have also have been beneficial as insulation in colder climates, and for providing the extra energy sources used during gestation and lactation (Weiss et al, 1989).

In someone who has the thrifty gene, whenever carbohydrates are consumed, the body releases excess insulin, which is called hyperinsulinemia. The overabundance of insulin quickly removes the glucose, storing it in adipose tissue (Bindon and Baker, 1997). The insulin also circulates in the individual longer, which helps glycogen to form more advantageously (Bindon and Baker, 1997). (Glycogen is a polymer of glucose.) The insulin also activates lipoprotein lipase, which will then help more triglycerides (fat) enter adipose cells by hydrolyzing it for transfer (Bindon and Baker, 1997). The insulin inhibits hormone sensitive lipase, keeping it from hydrolyzing triglycerides and releasing fatty acids into the plasma (Bindon and Baker, 1997). Therefore the insulin is allowing one's body to take in glucose and fats more efficiently and to hold onto fats longer.

Amerindian Background

Migration to the New World

Through linguistic, dental, and genetic evidence, scientists know that Native American ancestors migrated into the New World across Beringia, which is now mostly covered by water (Bahn, 1996). (See Figure 1 for a depiction of Berinigia as it was during the migration into the New World.)

Figure 1. Beringia

The migrants came from northeast Asia and Siberia, and eventually inhabited North, Central, and South America. The scientific evidence points to three waves of migration. According to genetic evidence discovered by analyzing divergences in the sequence variation of mtDNA, the first wave of migration took place about 42,000-21,000 years ago (Bahn, 1996). Dental and linguistic evidence is not conclusive, but points to a migration that took place more than 11,000 years ago (linguistic evidence), and more than 14,000 years ago (dental evidence) (Bahn, 1996). Therefore, scientists know that at least before 14,000 years ago migration into the New World began. The other two waves of migration are believed to have happened between 14,000 and 12,000 years ago, and 11,000 and 10,000 years ago (Bahn, 1996). There were two possible routes for the Paleolithic migrants to take in their migration southward from Asia and Beringia

(Bahn, 1996). One possible route was along the western continental shelf, which is now under water (Bahn, 1996). If this route was taken, the Native Americans would have utilized the resources of the coast, experiencing only gradual changes in food resources (Bahn, 1996). Another possible route of the migrants was the "ice free" corridor. The "ice free" corridor was the area between the two glaciers of North America, the Cordilleran and Laurentide continental glaciers.

Climate

According to Wendorf , the climate of the "ice free" corridor was harsh and possibly similar to the climate of modern day eastern Beringia. The climate there today varies, even within a season. In the summer the coast of Beringia experiences temperatures of about 50º F and the interior experiences temperatures of 60-70ºF, with occasional temperatures of 80-90ºF (Bering , 1995). In the winter the temperature reaches negative degrees. In January, the coastal average lows are –15ºF and the interior average lows are –50ºF (Bering, 1995). On average the winds average 8-12 mph, but during storms the winds can reach 50-90 mph, which can produce dangerous chill factors (Bering, 1995).

Diet

The immigrants into the New World were hunter-gatherers who depended on the resources of a very harsh climate. Roots, tubers, grass and other greens, shrubs, some berries, and bark were the only plant foods available to the Paleoindian migrants at this time (Ritenbaugh and Goodby, 1989). These plants were limited and seasonal (Ritenbaugh and Goodby, 1989), allowing them to supplement the migrants' diets, but not to provide a substantial or consistent part of the diet. Because they were not eating much plant material, their diet was low in fiber and carbohydrates (Ritenbaugh and Goodby, 1989).

Animals were the main dietary resource of the Paleoindians including marine and land animals, depending on whether the migrants lived on or near the coast. They hunted mega fauna such as mammoth and bison, as well as smaller game animals and fish . Because the land animals they were eating were undomesticated, they did not have much fat, but did provide a high amount of protein to the Paleoindian diet. Therefore, the Paleoindians in the New World had a low fiber, low carbohydrate, low fat, and high protein diet (Ritenbaugh and Goodby, 1989).

Because of the harsh climate, resources were sometimes scarce. There were also times, however, of plenty of resources. Anthropologists refer to this variation of plentiful or scarcity of food as periods of "feast or famine."

Pacific Islander Background

Migration to the Islands

About 5-10,000 years ago, Asian groups began migrating to the southern Philippine islands, and then to coastal New Guinea (Bindon, 1988). From here they migrated to the islands of Micronesia and Polynesia. (See Figure 2 to see the Micronesian and Polynesian islands.) It was about 3,000 years ago that Polynesians reached the Samoan Archipelago in the Pacific Ocean (Bindon, 1988). (Because the Melanesians genetic make-up shows that they are not directly related to the Micronesians and Polynesisans, the label "Pacific Islanders" will only refer

to Micronesians and Polynesians for the purpose of this paper. See Figure 2.)

Figure 2. Micronesian, Polynesian, and Melanesian Islands

Climate

The climate of Polynesia today is temperate with temperatures usually between the 60's and the 80's year-round (Lycos, 2003). However, when the Pacific Islanders were migrating, they did have to undergo some cold weather. Bindon (1988) says that the Pacific Islanders had to undergo cold stress, especially at night. The cold stress would have been intensified if the migrants, who were traveling in canoes, got wet (Bindon, 1988).

Diet

The diet of the migrating Pacific Islanders consisted mostly of marine resources, birds, bats, and the fermented crops that they carried with them, such as fermented breadfruit and banana (Bindon, 1988). It would not be until they could plant and harvest crops that they would have most of the vegetables of their diet, including breadfruit, banana, taro, elephant ear, and coconut (Bindon, 1988). Therefore, their diet would start out as mostly protein and low in fat and carbohydrates. According to Bindon (1988), food would have been scarce during this settlement period. After the cultivation of crops, however, they would have a diet low to moderate in protein, high in fat (coconut), and moderate to high in carbohydrates. The Pacific Islanders, like the Amerindians, experienced periods of feast and periods of famine.

Migratory Environment and Diet: Selective Pressures for the Thrifty Gene

In both the Amerindians and the Pacific Islanders, the thrifty gene seems to be an adaptation by natural selection in response to the following stress: cold stress, the feast or famine aspect of the diet, the need for body fat for gestation and lactation, and long periods of time with little or

no carbohydrates in the diet (especially in the case of the Amerindians). The thrifty gene allowed the individuals who possessed it to store fat more efficiently, allowing them to be better adapted to the migratory environments in which they lived.

Because of the lack of or low amount of carbohydrates in these populations' diets, the thrifty gene was selected for because it allowed the body to use carbohydrates more efficiently. The body quickly stored the carbohydrates, such as glucose, as fat, and would utilize them when they were needed. This was especially important in these populations because not only did they have low intakes of carbohydrates (or periods of low intake of carbohydrates as in the Pacific Islanders), but they would frequently experience periods of famine due to harsh weather and migration (Bindon, 1988; Weiss, et al., 1989; Goodby and Ritenbaugh, 1989).

The feast or famine aspect of the diet meant that at some periods of time both populations, the Amerindians and the Pacific Islanders, would have plenty of food, and at other times the food supply would be scarce. Because of this variation in the abundance of food, individuals who could more efficiently store fat could do so in times of "feast," saving energy resources for times of "famine." Because people who did not have the thrifty gene would be more likely to die in times of famine, and therefore not reproduce, then their genes were not be passed on as readily as the thrifty gene. This allowed for the selection of the thrifty gene in these populations.

Another stress that caused selection for the thrifty gene was cold stress. The cold stress of both the Amerindian and Pacific Islander migratory environments was extreme enough to select for the thrifty gene in individuals, allowing them to store fat in their bodies more efficiently. This storage of fat in their bodies would allow the individuals more insulation, protecting them from the cold of their environment (Weiss, et al, 1989; Bindon, 1988).

The thrifty gene also aided in female fertilization and lactation. This benefit of the thrifty gene during gestation would allow for the selection of individuals with the thrifty gene in a very direct way—through reproduction. This aspect of selection for the thrifty gene has not been addressed enough in the text that was reviewed for this paper. Because a woman will not ovulate without enough fat in her body, the extra fat in women who possessed the thrifty gene allowed them to be fertile for reproduction, and to therefore reproduce even in times of famine. The gene also allowed them enough resources for lactation, allowing the mother to also be able to nourish her infant(s) during these periods of food scarcity (Weiss, et al., 1989). Because of the reliability of the infants' nourishment, the child had a higher likelihood of survival. Since the women who possessed the thrifty gene could reproduce in times of famine when women who lacked the thrifty gene could not, then the women who possessed the thrifty gene had more opportunities in her lifetime to bare children than the women who did not possess the gene. Therefore, it seems possible that the women who had the thrifty gene would bare more children and have more surviving children than the women who did not have the gene. So, the possession of the thrifty gene allowed for more reproduction and a higher likelihood of survival of the infants, both factors being beneficial to the populations' survival, and to the passing on of the thrifty gene to individuals. The individuals who were born from the thrifty gene mothers, would possess the thrifty gene themselves, ensuring the survival of the gene into future generations. These children would grow up and pass on the gene as well. All these individuals could survive in the environment better than those who did not possess the thrifty gene, further ensuring the selection for the thrifty gene.

The Problem of Modernization

Modernization in North America and in the Pacific Islands has caused natives to abandon a lot of their traditional ways of life for the industrial way of life. This includes a new diet that is high in fat and sugar, and low in fiber. Also, the feast or famine aspect of their diet has been changed to having a steady food supply year round. Instead of their traditional active lifestyle, these groups have also become more sedentary. All of these changes have caused several health problems in these populations including NIDDM, obesity, and cardiovascular disease.

Because these groups possess the thrifty gene, their bodies are not adapted for these high amounts of sugar, and the Amerindians are not adapted for these amounts of fats. (The Polynesians have a traditional diet high in saturated fat because they eat coconut (Bindon; personal communication)) (It should be noted that the Pacific Islanders did have a traditional diet that consisted of 60% starchy foods (Bindon, 1988), therefore, they were perhaps more adapted to carbohydrates than the Amerindians.) The bodies of individuals in these two groups produce high levels of insulin, causing hyperinsulinemia, in order to compensate for the high levels of fat and carbohydrates (Bindon and Baker, 1988). Hyperinsulinemia causes the sensitivity of insulin receptor cells to decrease, causing the individual to become insulin resistant (Bindon, 1988). Insulin resistance can eventually lead to diabetes, which is very high among both Amerindians and Pacific Islanders.

In Figure 3, which was constructed from Bindon's research in Samoa (Bindon, class notes, 2003), one can see that the prevalence of NIDDM in Western Samoan men, who participate in a traditional lifestyle and eat a traditional diet, is 4 percent and for Western Samoan women 5.5 percent. For Americanized Samoan men, who would have a more modernized lifestyle and diet, the prevalence of NIDDM is 27.2 percent and for Americanized women is 20.6

percent. Therefore Samoan men who are living a more modernized lifestyle are 23.2 percent more likely to develop NIDDM than Samoan men living a more traditional lifestyle. The Samoan women in a modernized lifestyle are 15.1 percent more likely to develop NIDDM than Samoan women who live a traditional lifestyle.

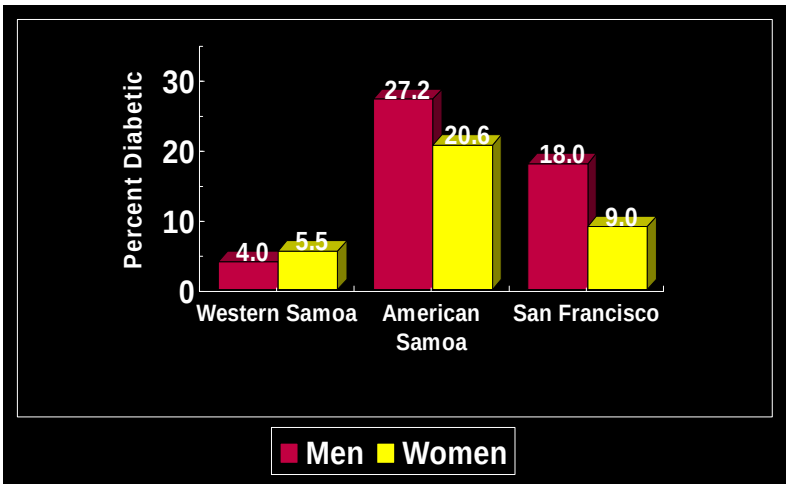

Figure 3: Prevalence of Diabetes Among Samoan Adults

To show a difference between populations with and without the thrifty gene, a comparison between Caucasians and Amerindians will be made. In a sample of Caucasion adults over age of 25, there is prevalence for NIDDM of 2-5 percent, with a maximum prevalence of 10 percent in older adults (Weiss, et al., 1989) . The prevalence of NIDDM in Amerindians varies among different tribes, however 20-30 percent prevalence rates are common, with the percentage rising as age increases. In 1997, the Pima, a tribe of Native Americans, were reported as having a prevalence rate of 50 percent (Shapiro, 1997). That prevalence rate for NIDDM is 45-48 percent higher than that for Caucasian adults.

Also, the bodies of both the Amerindians and Pacific Islanders are not adapted for the steady supply of food of a modernized diet. They are getting more food then their bodies are adapted for , along with the change in the content of the diet. This causes obesity, and contributes to the diabetes problem because they are not only eating food with higher fat and

sugar content, but they are also eating larger amounts of food than they traditionally would. This increase in the amount of the high fat and sugar content food causes them to even further the amount of insulin their body is secreting, in turn furthering the onset of insulin resistance and NIDDM.

In Figure 4, which was constructed from Bindon's research in Samoa (Bindon, class notes, 2003), one can see that the prevalence of obesity among Western Samoa men is 28.6 percent and in women 52.6 percent, while in Amerianized Samoa, the prevalence is 56 percent in men and 76 percent in women. There is a difference of prevelance of 27.4 percent between Western men and Americanized men and 23.4 percent between Western and Americanized women.

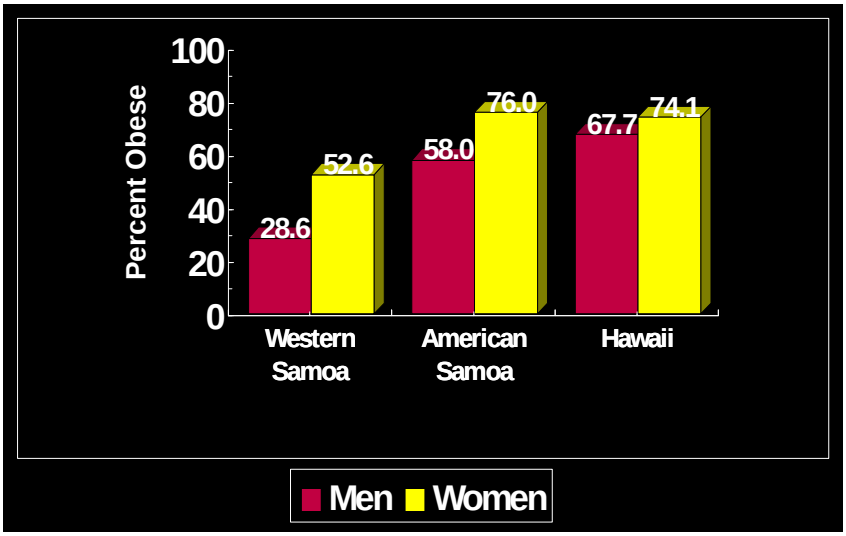

Figure 4. Prevalence of Obesity Among Samoan Adults

Another illness manifested in these modernized Amerindian and Pacific Islander populations is cardiovascular disease. As in other populations, a diet high in saturated fat and cholesterol can cause cardiovascular disease. Within these populations, the risk is even worse. According to the U.S. Department of Health and Human Services, Indian Health Service, as of 2002, heart disease was the leading cause of death among American Indians and Alaska Natives

(U.S. Department, 2002). In Figure 5 which was a part of Bindon's research in Samoa (Bindon, class notes, 2003), Western Samoa men showed a prevalence of hyptertension of 7.9 percent and women 6.4 percent, while Americanized Samoan men showed a prevalence of hyptertension of 32.7 percent and women 27.7 percent (Bindon, class notes, 2003). There is a difference of prevalence of 24.8 percent between Western and Americanized Samoan men, and 21.3 percent between Western and Americanized Samoan women.

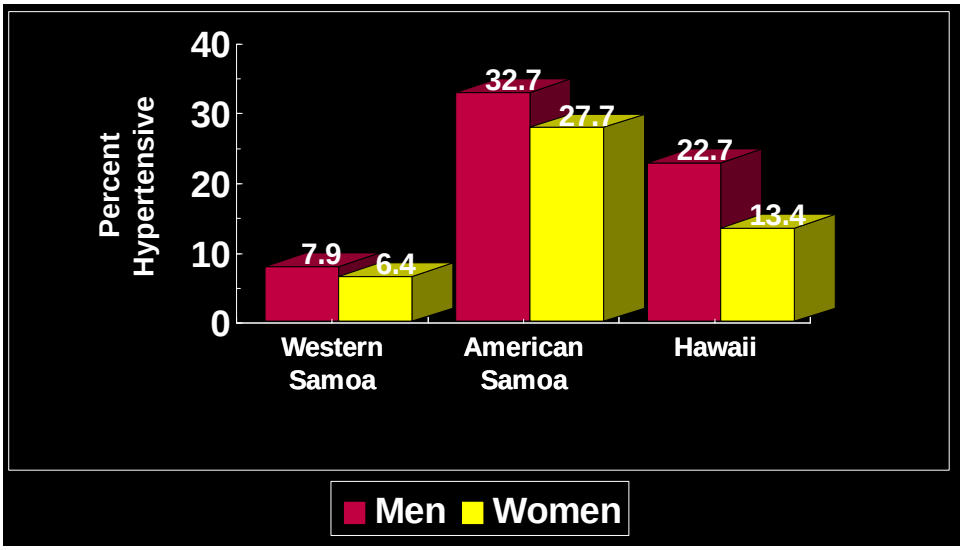

Figure 5. Prevalence of Hypertension In Samoan Adults

As one can see, cardiovascular disease, as well as NIDDM and obesity, has become a more prevalent illness to these two populations since modernization. In the past, Amerindians Pacific Islanders did not experience diabetes and these other illness because the populations had energetic balance and periods of famine (Bindon and Baker, 1997). In fact, NIDDM could possibly be controlled or prevented if these modern populations of Amerindians and Pacific Islanders were to be more physically active. The exercise would cause the receptor sites for insulin to become more sensitive to circulating insulin (Bindon and Baker, 1997).

Obesity is another problem among these groups, which is caused from the sedentary lifestyle, and also because of their bodies' efficient fat storage. An active lifestyle could also help these populations control their weight.

Amerindians also suffer from gallstones, gallbladder cancer, and abnormal cholesterol and lipid metabolism due to the New World Syndrome.

The New World Syndrome

The New World Syndrome is a term that refers to a syndrome that Amerindians are hypothesized as having, in which NIDDM, cardiovascular disease, obesity, gallstones, gallbladder cancer, and abnormal cholesterol and lipid metabolism are experienced (Ritenbaugh and Goodby, 1989). Most of these illnesses seem to be present because of the effects of modernization on the Amerindians, who possess the thrifty gene. However, the presence of gallstones, gallbladder cancer, and abnormal cholesterol and lipid metabolism, which are different illnesses from what the Pacific Islanders experience, show that there is something different going on in the Amerindian genes, allowing their illnesses, including the ones stemming from modernization with the thrifty gene, to be labeled as the New World Syndrome.

The Difference of the New World Syndrome of the Amerindians and the Thrifty Gene of the Pacific Islanders: Gallbladder Disease

According to Everhart and Lowenfels , American Indians are said to have one of the highest reported rates of gallbladder cancer in the world (Everhart, 2002). In Table 1, one can see that American Indians are listed at the top of the table for frequency of gallstone disease under "Very Common (30-70 %)" (Shaffer, 200). Pacific Islanders are not even listed in this table.

Table 1. Frequency of gallstone disease in different countries.

Very common (30-70%)	Common (10-30%)	Intermediate (<10%)	Rare (approx. 0%)
American Indians	United States (whites)	United States (blacks)	East Africa
Sweden	Canada (whites)	Japan	Canada (Inuit)
Chile	Russia	Southeast Asia	Indonesia
Czechoslovakia	United Kingdom	Northern India	West Africa
United States (Hispanics)	Australia	Greece	Southern India
	Italy	Portugal	
	Germany		

In fact, information for gallbladder illness rates could not be found for Pacific Islanders during the research for this paper. The lack of evidence for gallbladder illnesses for Pacific Islanders suggests that gallbladder illnesses are not a serious problem for Pacific Islanders. Because both the Amerindians and the Pacific Islanders possess the thrifty gene, it seems as if there must be another factor causing gallbladder disease in Amerindians beside the thrifty gene.

The high prevalence for gallbladder disease in Amerindians seems to have something to do with the New World Syndrome, which involves a difference in lipid metabolism (Weiss , et al., 1989). The gallbladder produces bile, which is secreted into the digestive tract to help digest fats. Insulin, which reaches high levels in Amerindians, stimulates cholesterol synthesis by acting on the cells of the intestine (Ritenbaugh and Goodby, 1989). This causes the bile to become saturated by cholesterol (Ritenbaugh and Goodby, 1989). When the bile acids decrease, and there is an increase in cholesterol saturation of the bile, gallstone disease may be an underlying factor (Ritenbaugh and Goodby, 1989).

Areas for Further Research

Lipid Metabolism of Amerindians

If insulin is the cause of cholesterol saturated bile, then why do Pacific Islanders, who also have high levels of insulin, not have high rates of gallbladder stones and disease? Perhaps it

is possible that there is another factor causing cholesterol saturated bile in Amerindians, or perhaps there is something different in Pacific Islanders' genes that causes them to escape high rates of gallbladder disease. A possibility for lessened rates of gallbladder disease may be that, unlike the Amerindians, the Pacific Islanders had fat and carbohydrates in their diet. This could have caused their lipid metabolisms to select in different ways than the Amerindians did . More research must be done to see if it is indeed the different lipid metabolism that causes Amerindians to experience New World Syndrome, including gallbladder disease. Also, research must be done to find out why Amerindians developed a different lipid metabolism, if that is the case. It is possible that a diet low in fat and carbohydrates, and high in protein had something to do with the development of a different lipid metabolism? This is only conjecture, and must be further studied by researchers.

Possible Glacial Climate and Gallbladder Disease Correlation

There is perhaps a correlation between arctic/glacial climates and the selection for genes that predispose modernized populations to gallbladder disease. Amerindians migrated either through the "ice-free" corridor, or on the other side of a glacier in North America. The cold, harsh climate was one of the reasons that the thrifty gene was selected for. The lack of carbohydrates and fats were other reasons that the Amerindians selected for the thrifty gene. There was a lack of carbohydrates and fats because the cold, harsh environment in which they lived made it hard for plant life to grow, and the animals that they ate had little fat.

In other parts of the world, such as Scandinavia, Russia, and Eastern Australia, there were also glaciers at this time. These glaciers would have caused an environment to exist that was very similar to the environment that the Amerindians encountered during their migration near the glaciers of North America. If the people near the glaciers in Scandinavia, Russia, and Australia

lived in similar conditions, had similar diets, and lived in about the same time as the Amerindians, is it possible that there would be selection for the same types of genes in those populations as in the Amerindian population? If so, then it is possible that they might also have a gene that predisposes them to gallbladder disease. When one looks at the Table 1, one can see that the other two groups under the "Very Common" column, other than Amerindians, are Sweden and Czechoslovakia. Sweden is in Scandinavia, and Czechoslovakia is south of Scandinavia, approximately 500 miles away. In the next column, "Common," Australia and Russia are listed. Because the ancestors of these groups of people lived near glaciers, in very harsh and cold climates, it is possible that that is the reason that they are also predisposed to gallbladder disease. At this time, however, this is purely conjecture, and must be further researched and evaluated.

Conclusion

Both the Amerindians and the Pacific Islanders suffer from high rates of NIDDM, cardiovascular disease, and obesity, the effects of modernization on the thrifty gene that they possess. Amerindians also have high rates of gallbladder disease, which seems to be associated with their thrifty gene. However, Pacific Islanders who also possess the thrifty gene, do not have high rates of gallbladder disease, and seem to have almost no instance of it. It is hypothesized that the high rates of gallbladder disease in Amerindians are the result of modernization and are associated with the New World Syndrome.

It is perhaps a different lipid metabolism that causes gallbladder disease in the New World Syndrome. However, research must be done to discover if this is true, and if so, why the different lipid metabolism developed.

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