WHY DO THE PEOPLE OF BOUGAINVILLE LOOK UNIQUE?

SOME CONCLUSIONS FROM BIOLOGICAL ANTHROPOLOGY AND GENETICS*

by Jonathan Friedlaender

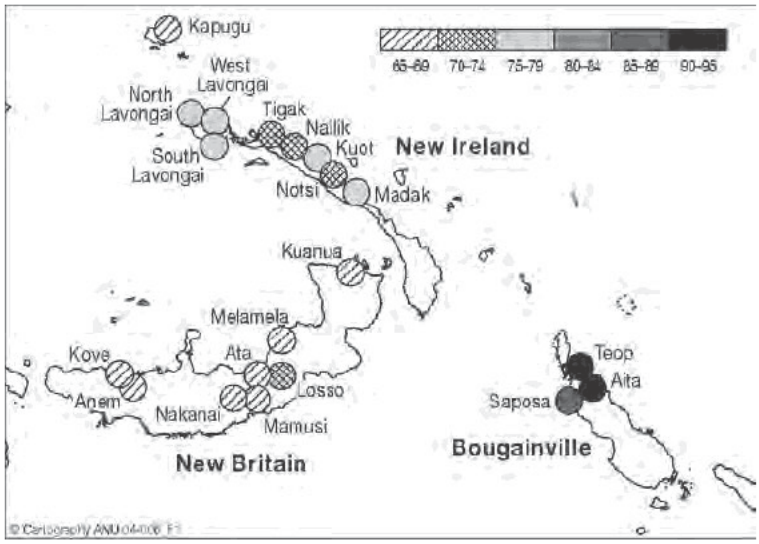
One of the great puzzles of Bougainville is why its people are so distinctive in appearance from most other people in the region, particularly why they are so black. Did some Africans somehow move into this area thousands of years ago? Or were these people descendants of the 'original' inhabitants of the entire region, who were all black-skinned? Another explanation was that they simply had lived there, under the tropical sun, long enough to develop their jet-black colour independently from other black-skinned groups. I have been told by more than one Seventh-Day Adventist from Bougainville that there are also Biblical interpretations suggesting they are descendants of Ham that wandered into this part of Island Melanesia. I have had this question of the origins of Bougainvilleans in my mind for a very long time. Beginning in 1966, I have been involved in studies of questions relating to the health and biology of people in Bougainville, as well as on nearby islands. As a graduate student, I took part in The Harvard Solomon Islands Expedition, which was led by Douglas Oliver and Albert Damon from 1966 to 1972 that surveyed Aropa Valley Nasioi, Nagovisi, and Aita as well as groups on Malaita, Ontong Java, and Ulawa [Friedlaender 1987]. Over the following decades, I have led expeditions back to Bougainville, Malaita, and Ontong Java, and expanded the coverage to New Ireland, Lavongai, and New Britain, but Bougainville always served as the reference and centrepiece. On Bougainville, I focused on the region on the east central coast with the greatest language diversity — from the Aita and Rotokas region near Wakunai and Asitavi, down through the Eivo, Simeku, and North Nasioi region to old Uruava Village

(Arawa) and Rorovana [Friedlaender 1975]. This included north and south Papuan-speaking groups, as well as some Austronesian speakers. We later surveyed villages in the Solos and Halia areas of Buka, some Siwai, and most recently, a few Saposa and Teop Austronesian groups in the north. The total number of people included in these surveys on Bougainville, one way or another, is roughly 2,000. At this point, there are some fairly clear conclusions I can offer on the causes of the distinctive appearance of the people of Bougainville, and also on some related issues. These will be presented as a series of questions and answers.

How Uniquely Black are Bougainville People, and is Anyone Else in the Region as Black?

The science of skin colour evaluation has become considerably more exact in the last decade, so that this is an issue we can answer directly, largely due to the work of Heather Norton [Norton et al. 2004; 2005]. The short answer is that a systematic study of skin colour (using the DermaSpectrometer instrument, which measures the amount of dark pigment, or melanin, in one's skin)[1] confirms a number of facts. Compared with the people of New Ireland, New Britain, and New Guinea, Bougainvilleans are remarkably black-skinned judged by their average 'melanin index' readings [Map 1]. There is only a little overlap in the distributions of Bougainville skin colour with these others [see Figure 1]. The next darkest group in our surveys comes from Lavongai (New Hanover) and northern New Ireland. New Britain people are considerably lighter. New Guinea peoples are lighter still. In other words, there is a gradual shift or gradient in skin colour moving from New Guinea east to Bougainville. While we have not systematically surveyed people from the Shortlands and Western District of Solomon Islands, a few individual readings on people from there, and from impressionistic visits to Gizo, suggest to me that the people there would also join this most black group — once referred to by Douglas Oliver as 'The Black Spot of the Pacific' [Oliver 1991: 3]. Peoples further to the south and east, including Guadalcanal, Malaita, Santa Cruz, and Vanuatu, are all considerably lighter, to judge from our earlier, less technically proficient, surveys.

In broader comparisons, Bougainville people are, on average, darker as a group than African–Americans [Figure 2 — see Norton et al. 2004]. They are in fact blacker than most Africans. We do not know of any darker groups. The major qualification here is that systematic surveys of skin colour readings with the sophisticated DermaSpectrometer instrument have not been taken widely in a variety of populations in Africa or Australia.



Map 1. Skin colour in Island Melanesia. Average M index readings for selected populations.

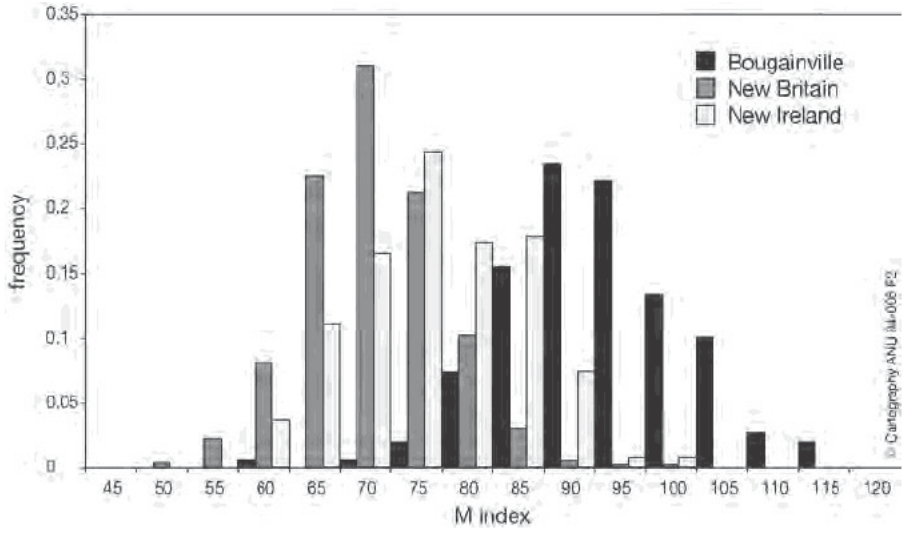


Figure 1. Distribution of M index skin reflectance values for Bougainville, New Ireland, and New Britain.

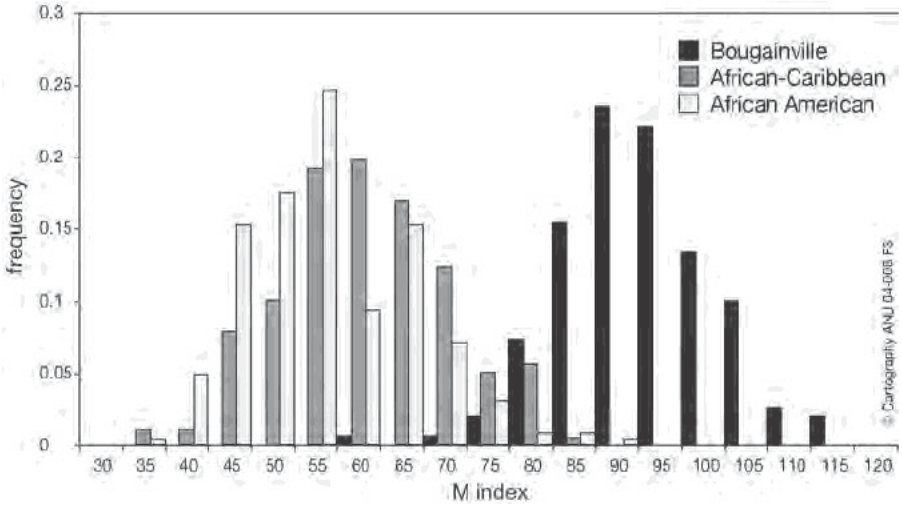
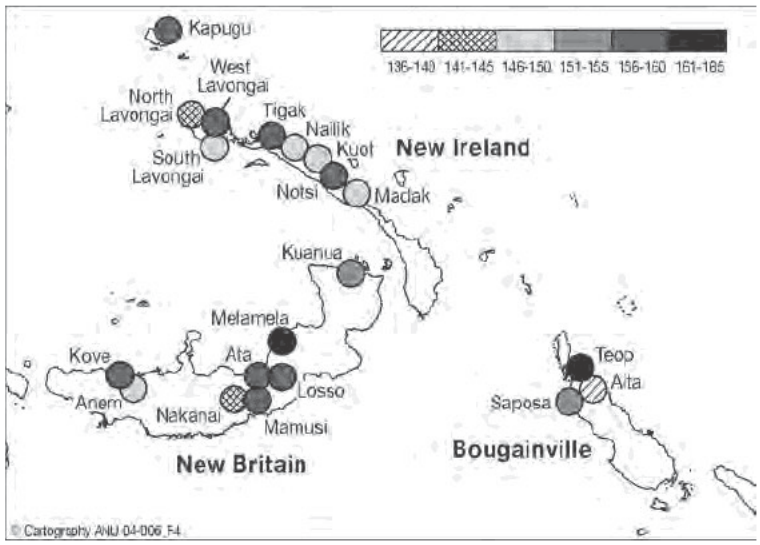


Figure 2. Comparison of Bougainville skin reflectance values with selected other heavily pigmented populations.

Are Some Bougainvilleans Blacker than Others?

Many people have told me over the years that south-Bougainville groups, particularly the Siwai and Buins, were blacker than groups from other parts of the island. The DermaSpectromter readings do not reveal any significant distinctions among the groups we have surveyed, although this only includes a few Siwai and no Buins. Our skin pigmentation survey concentrated on north Bougainville, and although some people there told me the Aita were lighter than their neighbours, we did not find any difference. Austronesian-speaking groups in north Bougainville and Buka do not differ from the Aita in skin colour.

What did show up as an internal Bougainville distinction is that Aita people have significantly lighter hair pigmentation readings than the Austronesian-speaking groups of north Bougainville that were covered in the survey. The Aita hair values are lighter than any we took in New Britain and Lavongai, as well, but some inland Papuan-speaking groups on those islands (Anem, inland Nakanai, and west Lavongai) are almost as light as the Aita [Map 2]. This is an intriguing finding, which could be interpreted to mean that early Papuan settlers had lighter hair colour than later Austronesian migrants, but this has to be reconciled with other regions in Island Melanesia where light-coloured hair is present, particularly the Austronesian-speaking people of north Malaita.



Map 2. Hair colour readings in Island Melanesia. Average M readings for selected populations.

Does this Uniform Black Skin Colour Across Bougainville (and Nearby Regions of Western District) Mean that People there are all Very Much Alike in all their Genes and Biology?

The answer is, surprisingly, no. Besides the clear differences between Bougainville peoples and those from New Ireland, New Britain and elsewhere in the region, our studies have revealed that the people of Bougainville are genetically remarkably heterogeneous from one section of the island to the next. I do not know of any other area as small as Bougainville that has as much long-standing native biological variation that has developed over many thousands of years. New Britain comes close, but it is almost three times the size of Bougainville. The biological differences within Bougainville tend to follow distinctions of language as well as of neighbourhood. People who speak the same language and are from the same region of Bougainville are likely to be more similar than people from different areas. While this may seem to be a ridiculously obvious statement, the fact that there are so many distinctions among the different groups in such a small island is remarkable and, to my knowledge, is not matched outside Melanesia.

SUMMARY OF FINDINGS ON THE MANY BIOLOGICAL DIFFERENCES IDENTIFIED

A number of biological differences distinguish north and south-Bougainville populations that parallel the linguistic divide between north and south-Bougainville Papuan languages. The Aita, Eivo, Rotokas and to a lesser extent the north Bougainville and Buka Austronesian speakers cluster together, often contrasting with the Nasioi, Nagovisi, and Siwai from the south, along with the Austronesian Torau-speaking Rorovana. For example, with regard to the shape of the head and body, northern mountaineers have broader chests and faces than the smaller and leaner southerners, who tend to have longer and narrower noses and faces, and also longer heads [Friedlaender 1975; Rhoads 1987]. Northern Austronesian-speaking peoples, including those from Buka, tend to be big, but with long heads similar to south-Bougainville Papuan groups. It may be, however, that their large size is due to better nutrition rather than heredity.

Finger and palm print patterns are often revealing about population relationships, and they reinforce the distinctiveness of Bougainville Papuan speakers, particularly the southern Nasioi and Nagovisi [Friedlaender 1975; Froehlich 1987]. They have simple finger and palm prints for a Pacific population, meaning that the ridges on their fingertips and hands form fewer swirling and looping patterns. Prints from other Bougainville groups are less distinctive from other regional groups, and particularly cannot be distinguished from those of Austronesian-speaking groups from Island Melanesia, New Guinea, and Micronesia. Prints from New Guinea Papuan groups and Australian Aborigines all tend to be considerably more complex, but in different ways. As detailed in Froehlich [1987], some groups tend to have more swirling and looping patterns on the thumb pad and tip (New Guinea Papuans), others tend to have more loops and swirls on their middle three fingertips (Australian Aborigines), and others have more print complexity generally (Polynesians). Again, the important conclusion is that Bougainville groups are highly diverse in these characteristics, but taken together, Bougainvilleans constitute a centre of biological distinctiveness in the region.

Tooth sizes and shapes also vary widely among Bougainville groups, but these differences do not form readily interpretable patterns. The Bougainville people with the smallest teeth are the Rotokas from the northern mountains [Harris and Bailit 1987], and south-Bougainville Papuan groups cluster tightly together in a number of other tooth characteristics. A particular dental characteristic called the shovel-shaped incisor, which is commonplace in people with a North Asian or Native American heritage, has an unusual distribution in Bougainville. It is low in frequency in South Pacific native populations from

Australia to Indonesia and Polynesia. In Bougainville, it is also generally low, except for the Aita and Rotokas, who have moderate frequencies [Dobrich 2004]. This is probably just another example of how variable different Bougainville groups can be, rather than indicating some distant relationship of these groups with North Asians and Native Americans. As a general comparison, Bougainville tooth sizes are about the same as other Island Melanesians, and are intermediate between the large Australian Aboriginal values and smaller South-East Asian or Polynesian averages.

Blood Genetics

Researchers in human genetics are especially preoccupied with the analysis of blood samples. At first, this was because particular parts of the blood (especially protein molecules on the surface of the red blood cells as well as other proteins floating in the clear blood plasma) varied among people due to very simple distinctions in their inheritance. There is a direct connection between each of these aspects of the blood and a specific gene a person inherits from each parent. The best known example of this sort of variation involves the ABO blood types, so important in compatible blood transfusion. Very specific differences in a particular protein determine a person's ABO blood type (people can be either types A, B, AB, or O). These differences are the results of distinctions between people at one particular gene (there are tens of thousands of genes in each human, and for the most part, we inherit one of each kind from each parent, making a pair of each kind). For example, a person with type O blood will have a pair of O genes, one from the mother and one from the father. A person with type AB, with a different kind of protein, has inherited an A gene from one parent and a B gene from the other — and so on.

The important point for questions of population history is that these sorts of characteristics (unlike head shape, finger ridge counts, tooth size, and so on) directly tell us about a particular genetic difference among people and populations. Of course, the ABO gene is only one gene out of thousands, so it offers only a very small window on the total picture, but it is unambiguous.

For example, my earliest studies in the east-central region of Bougainville showed that everyone in the Eivo and Simkeu region was type O — there were no genes for A or B in people from that entire region, while A was present and fairly common in both the south and north [Friedlaender 1975]. This was the first clear suggestion we had that there were clear genetic distinctions among different groups in Bougainville. Subsequently, our group has analysed many more populations in the island and region, and analysed different genes — the gene that determines the Rh factor, genes that determine various anemia deficiencies, and

a number of unknown effect [Friedlaender and Steinberg 1970; Friedlaender 1971a and 1971b; Friedlaender, et al. 1971; Friedlaender 1975; Rhoads and Friedlaender 1975; Sokal and Friedlaender 1982; Rhoads 1987; Kamboh, et al. 1994; Jobes, et al. 1999; Ryschkewitch, et al. 2000; Cann, et al. 2002; Yanagihara, et al. 2002; Robledo et al. 2003].

The conclusions we drew from these earlier genetic studies largely confirmed and complemented the findings from the skin colour, fingerprints, teeth, and head and body shape studies. Early on, we found one variant that changed in frequency from north to south Bougainville in a very regular and dramatic fashion [Friedlaender and Steinberg 1970]. This is the Kv1 (or Inv) gene, which shifts from a frequency of over 0.80 in the Aita down to a low of 0.32 in the south. A few other gene distributions showed similar patterns, emphasising the variation within Bougainville groups along the lines of language and region. We did not find any gene variants that were entirely restricted just to Bougainville or the region, but there were many variants that were especially common there, or in different parts of the island. In larger world-wide comparisons, these differences, taken together, suggest Bougainville populations have a long separate history from New Guineans, Australian Aborigines, and Asians. There are some clear links to some other Island Melanesian and central Pacific groups (Micronesians and Polynesians), but indications of a long and in some ways separate history remain.

Mitochondrial Genetics — Recent Developments

We have been fortunate that recently developed techniques of genetic (DNA) analysis now allow a reuse of some blood samples extending back to the first expeditions of our group in 1966. The most interesting new finding concerns variation in an unusual set of genes that occur in the mitochondrion, a part of the cell which is inherited only through the mother's lineage. This is possible because, unlike other DNA (that exists in the paired maternal and paternal chromosomes in the nucleus), the mitochondria are outside the nucleus of each cell, including each egg, but are not in the parts of the father's sperm that are joined with the egg at fertilisation. This means that men (who have mitochondria identical to their mothers and sisters) cannot pass these on to their own children. Mitochondrial variation therefore reflects past marriage and migration patterns of women only. While this is something of a disadvantage and presents only 'half the picture', the major advantage is that mitochondria very rapidly accumulate new variants, or mutations, and scientists have figured out a way to tell which variants are new and which are older. Newer ones that may have appeared only a few hundred years ago should have only spread to a few people in a small region — perhaps even a single village. They

should also be inherited in only one or two combinations, called haplotypes, with other variants. Older mutations would be expected to be more widely distributed among different peoples, and should occur in a variety of combinations with other, newer, mitochondrial variants [see Friedlaender et al. 2005].

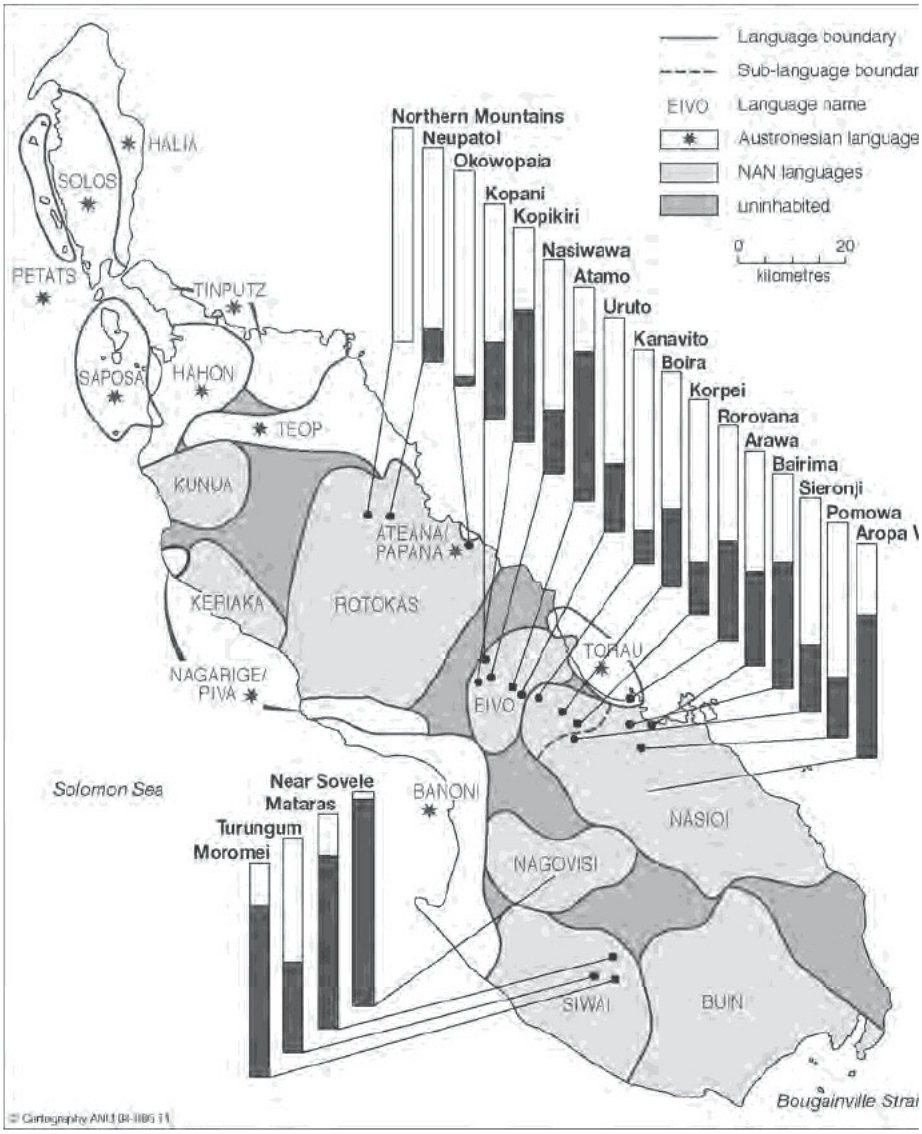
NEW CONCLUSIONS

New conclusions from the mitochondria studies are still coming in, but some are already clear. Bougainville populations had been heavily (though unevenly) influenced by off-island migrations to an unexpected extent [Merriwether, et al. 1999], specifically from Austronesian sources. These influences are most apparent in south Bougainville, and may account for the north–south gradient in a number of other characters that we had previously attributed to the Papuan language distinctions within the island. This is because one particular missing section of nine letters within the DNA of the mitochondria (mtDNA), in combination with three other specific mtDNA variants, that has been tied to Austronesian-speaking groups, including many Micronesians and Polynesians, is common in south Bougainville, and this would seem to represent Austronesian influence [Map 3].

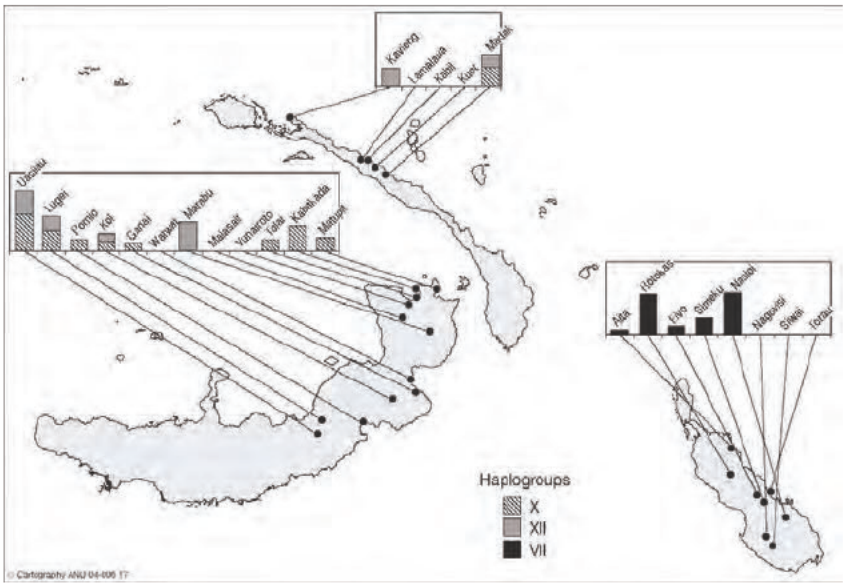
Two other mtDNA combinations, referred to as the P and Q variants or haplogroups, occur in the general region, particularly the interiors of New Guinea, and appear to be very old [Map 4]. P is also found among Australian Aborigines, and Q has been detected as far west as Indonesia and Malaysia, but only in very low frequencies there. In Island Melanesia, Q occurs in some eastern sections of New Britain and in north Bougainville groups such as the Aita, Rotokas, Eivo, and Simeku. P is found in much lower frequency in the region, notably in north Bougainville Papuans and Vanuatu and New Caledonia.

Some other mtDNA variants are more restricted to specific regions within Island Melanesia and have not been found elsewhere, including New Guinea [Friedlaender et al. 2005]. Their relationships are very distant and old, and indicate just how long people have lived in Island Melanesia. Some apparently have their origins in either East New Britain (Tolai or Baining), or West New Britain (Ata and Kol) but are missing in Bougainville [See Figure 3].

One particularly interesting variant combination, which we call Haplogroup VII [defined by Gentz et al. 2000, and also presented in Map 4], is most common in north and central Papuan-speaking Bougainville populations, with highest frequencies among the Rotokas of north Bougainville. Outside Bougainville, we have not detected it, except for one Solomon Islander. We have not yet been able to link this variant with any others in the region, including Australia, Indonesia,



Map 3. Frequency distribution of mtDNA haplogroup B in surveyed Bougainville villages. This variant was apparently introduced by Austronesian-speaking migrants. Note the high frequency of the variant in the south, and its absence in the north mountains.



Map 4. Frequency distribution of two very old indigenous mtDNA haplogroups (P and Q) in the south-west Pacific. These occur throughout the region, but are rare elsewhere. 'N' values at top indicate the number of tested samples.

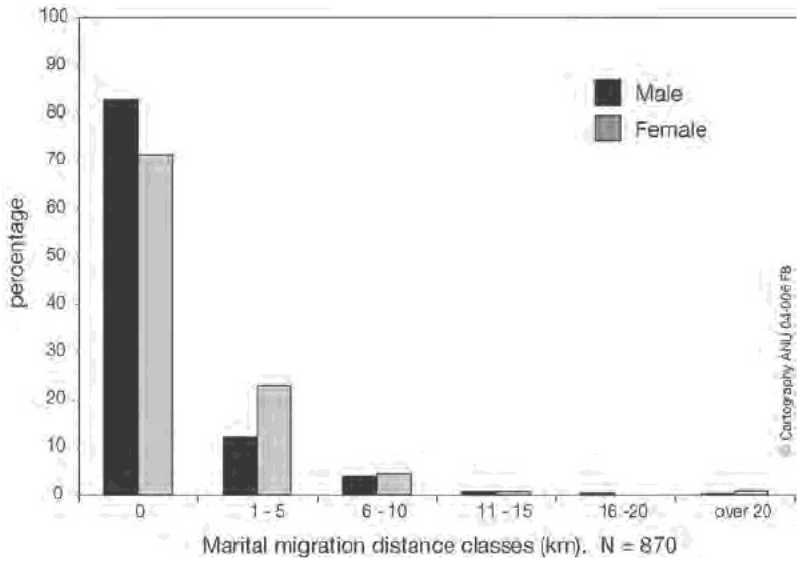


Figure 3. Frequency distribution of three mtDNA haplogroups (VII, X, and XII) that are essentially limited in their distributions to sections of Island Melanesia. Note haplogroup VII is apparently limited to north Bougainville.

South-East Asia, or East Asia, for that matter. It presents a major question and may well hold the key to questions of ultimate relationships of Bougainville populations to those in India and Africa. It is clearly very old.

The most important finding of our genetic study to date is the extraordinary mtDNA diversity in Island Melanesia, with specific and separate centres in New Britain and Bougainville. The geographically patterned heterogeneity certainly recalls the unresolved relationships of Papuan languages in the same region. As with languages, the more remote regions of the largest Melanesian islands retain the oldest genetic signature.

WHY IS THERE AS MUCH GENETIC VARIATION AMONG DIFFERENT BOUGAINVILLE GROUPS?

The exceptional internal variation on Bougainville has more than one cause. Bougainville has been inhabited for a very long time, allowing many new genetic variants to develop there. The population was never large. This was at least partially the result of extremely high rates of malaria. Settlement was very unevenly distributed across the island, which meant that the different small groups would tend to diverge genetically over time. People tended to marry very close to home, which meant that once genetic distinctions developed, they had an excellent chance of being maintained in that same village or neighbourhood, and did not spread widely. And finally, there clearly have been some major later migration influences from external sources, particularly from Austronesian-speaking groups in the last thousand years or so. The same forces have acted in similar ways to make for differences among New Britain populations, and also those from New Guinea. Smaller island populations in the region are far more homogeneous.

The limited rate of marriages among people from different villages is especially interesting and deserves more comment. By asking married people from one place where they were born, one can plot the numbers of married people born in the same village (zero kilometres from their marital residences); those born a short distance away (one to five kilometres from their residences), and so on for those who have moved from further and further away [see Figure 4]. The figures for people living in Bougainville villages away from the coast, during the period 1966 to 2003, did not change appreciably, and were very different from what one finds in urban areas worldwide, where most married people have moved substantial distances from their birthplaces. Basically the same profile existed for men and women. This is undoubtedly a key reason for the genetic variation from one section of Bougainville to the next. Even with the disruptive effects of World War II, the pattern of marital migration in Bougainville was very restricted in the

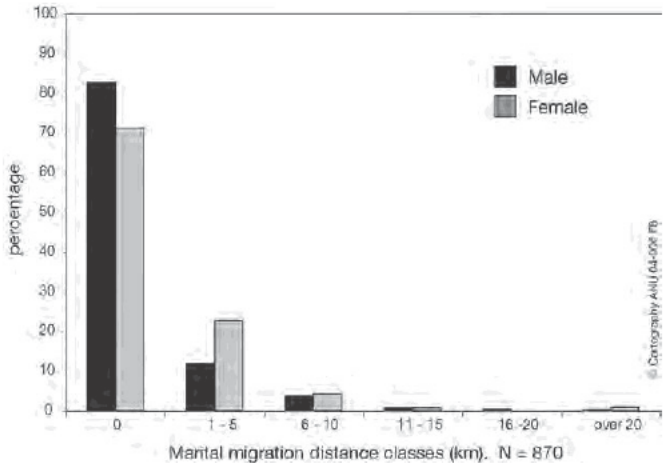


Figure 4. Bougainville marital migration rates.

inland regions, with almost everyone setting up marital residences only a kilometre or two from their birthplaces [Friedlaender 1975: 78]. This pattern very likely characterised earlier periods as well, especially prior to the colonial era. People were afraid to move far because of pervasive feuding, head-hunting, and the fear of malevolent ancestral spirits. We have found the same restricted marital migration rates in inland New Britain, as well.

However, during my visit in 2003 to north coastal Bougainville (the Saposa, Buka, and Teop regions), I found that the marital migration pattern there was different. Many more people had moved from one place to the next by the time they settled down to have families. If this was true in earlier generations, one would expect genetic variation to be more evenly spread out and consistent from one beach location to the next, as opposed to the inland regions. This may also explain why big islands such as Bougainville and New Britain have a great deal of internal genetic diversity, while smaller islands without large mountainous interiors such as New Ireland, are more homogeneous.

In sum, because Bougainville has been settled for so long, and because the inhabitants were relatively few and isolated from one another for most of the time since first settlement, a number of genetic differences have developed within the island's population, as well as between Bougainville and other islands in the region. While most of the differences are only in degree, a few variants are apparently restricted in their distributions to Bougainville or even to particular sections of the island.

Endnotes

* This paper represents a summary of a large body of work and participation by many people over 30 years. It relied from the beginning on the goodwill and support of the people of Bougainville, including many co-workers, friends, and assistants as well as the many hundreds of participants. Scientific collaborators have been acknowledged in references, but special thanks go to George Koki, Andrew Merriwether, Heather Norton, and Daniel Hrdy. Much of the research was performed in affiliation with the Papua New Guinea Institute for Medical Research in Goroka, and was supported by the United States National Science Foundation, Wenner-Gren Foundation for Anthropological Research, and the National Geographic Society, as well as Temple University, the United States National Institutes of Health, and the University of Michigan.

1. Skin and hair pigmentation were taken using a DermaSpectrometer (Cortex Technology, Hadsund, Denmark), a narrow band reflectance spectrophotometer. Details are provided in Norton et al. 2004 and 2005. The DermaSpectrometer measures the primary colour-giving elements of the skin, hemoglobin (red) and melanin (brown). The reflectance of narrow-band light in the red spectrum results in an estimate of the melanin content of an individual's skin, using the following equation:

   M = log10(1/% red reflectance), where M = Melanin Index.

   Conversely, erythema, or redness of the skin, is calculated by subtracting the absorbance due to melanin from the absorbance of the green filter:

   E = log10(1/% green reflectance) — log10(1/% red reflectance), where E = erythema.

   The M index, as computed by the DermaSpectrometer, is useful in studies of pigmentation variation because it measures the amount of skin pigmentation that is due primarily to the effects of melanin, without any confounding effects from hemoglobin. The upper inner arm was selected as the measurement site because it is a region of the body that is generally unexposed to UVR, allowing for a more accurate measurement of constitutive rather than facultative skin pigmentation. Three measurements were also taken of the hair at the crown.