NATIONAL CENTER FOR CASE STUDY TEACHING IN SCIENCE

Genetics and a Transcontinental Romance

by
Pamela Kalas
Departments of Zoology and Botany
The University of British Columbia, Vancouver, BC, Canada

Part I – They Don't Care About My Shiny Blond Hair?

Annika, a Swedish graduate student in anthropology, was on her way to her second field season. She would be working in a remote village in the Solomon Islands, Melanesia, documenting the traditional biological knowledge held by the locals.

Upon her arrival in Honiara, Annika was surprised to see that, contrary to her previous experiences in tropical and sub-tropical areas, her Northern European blond hair did not attract any particular attention. In fact, she noticed that blond hair was quite common among the very dark-skinned Solomon Islanders. While she waited for transportation to her study site, Annika started to speculate about the mechanisms that lead to different frequencies of hair colors among different populations, and about the origin of Solomon Islanders' blond hair in particular.

Questions

1. What are some of the factors that affect a person's hair color?
2. Propose a hypothesis that explains the distribution pattern of blond-haired individuals in Europe shown in Figure 2.
3. Propose at least two hypotheses to explain the origin of blond hair in the Solomon Islands population.

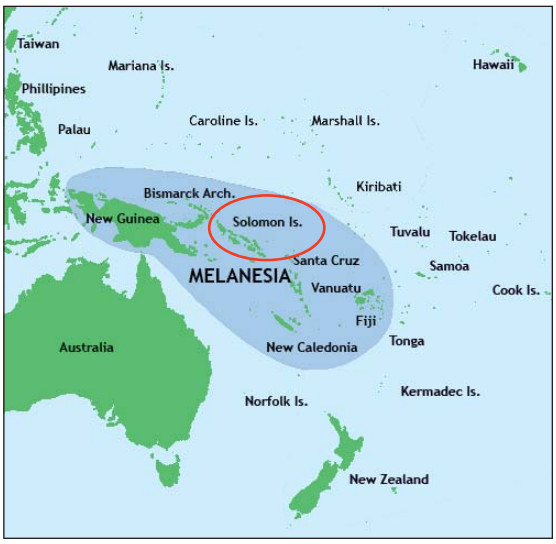

Figure 1. Melanesia, a group of Pacific islands, which includes the Solomon Islands (circled in red).

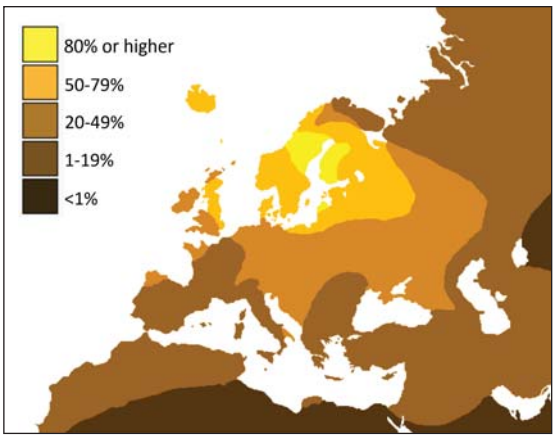

Figure 2. Estimated frequencies of light (blond) hair color in different areas of Europe and North Africa.

Part II – It's a Girl!

Two years into her fieldwork, Annika had learned a great deal about the local village traditional culture and biological knowledge. She had also become part of the community by regularly contributing to the village activities, learning the language, and … falling in love with a local gentleman named Tane. When the couple got married, the entire village took part in the wedding celebration.

When it came time for Annika to contact her supervisor with an update on her latest research findings, she also relayed her personal good news, namely that she and Tane had just had a baby girl. During the course of the conversation, Annika mentioned that she was surprised that her daughter had very dark hair. "Tane is blond, I am blond … I always thought blond parents could only have blond kids!" Her supervisor told her not to worry; hair color could change dramatically during the first year of a baby's life.

The child's hair color, however, did not change, leaving her parents completely baffled.

"In Sweden, blond parents always have blond children," said Annika.

Tane replied, "Same here; you can ask anyone on the island. Blond kids can have dark-haired parents, but two blond parents always have blond children."

Meanwhile, rumors started to spread throughout the local community.

Questions

1. Identify a person with naturally blond hair in your family or in your group, and draw his or her family history in the form of a pedigree for the trait "blond hair." Based on the pedigree, what is the mode of inheritance of blond hair?
2. What assumptions do Annika and Tane make when they reason that since blond couples in Sweden and in the Solomon Islands always have blond children, their own baby daughter should also have blond hair?
3. Propose at least two hypotheses to explain the unexpected hair color of the baby girl.
4. How could you test each of the hypotheses proposed above? For each hypothesis, briefly outline an appropriate and *feasible* experiment, and describe what the expected results would be if your hypothesis were accurate.

Part III (A) – Geneticists to the Rescue

Figure 3. The title of a *Science News* article reporting the finding of Kenny and colleagues in 2012.

Annika was aware of the stir that her daughter's hair color was causing in the village. During her next trip to town she spent some time searching the Internet for information about the inheritance of hair color. She came across several news reports such as the one in Figure 3 and quickly learned that in May 2012 Kenny and colleagues reported the results of a comparative genome-wide survey of native Melanesian people with dark and blond hair, respectively. Interestingly, the researchers found a very strong correlation between blond hair and homozygosity for a novel mutant allele of the *TYRP1* gene. This allele was found to be quite common in the Solomon Islands (estimated frequency of 26%), but virtually absent in Europe, Africa, Asia or the Americas (Kenny et al., 2012). In other words, Europeans, Africans, Asians and Native Americans are virtually all homozygous wild-type for *TYRP1*.

Questions

1. What do these data suggest about the origin of blond hair among Solomon Islanders? Which of the hypotheses you proposed in Question 3 of Part I do they support or contradict?
2. How could this information help Annika and Tane explain their daughter's dark hair color to the rest of the village?
3. Using symbols of your own choosing and the information thus far, assign genotypes to Annika, Tane, and their daughter. If the couple has another child, what hair color should they expect it to have?
4. In Melanesia (which includes the Solomon Islands) it is estimated that about 5–10% of the native population has blond hair (Waugh, 2012). Do the findings reported by Kenny et al. (2012) provide any evidence supporting the idea that Solomon Islanders might have a preference for mates with a given hair color? In other words, is there any evidence that mating is not random with respect to hair color? Use specific, quantitative data to support your explanation, and state any assumptions you are making.

Part III (B) – Geneticists to the Rescue

Figure 3. The title of a *Science News* article reporting the finding of Kenny and colleagues in 2012.

Annika was aware of the stir that her daughter's hair color was causing in the village. During her next trip to town she spent some time searching the Internet for information about the inheritance of hair color. She came across several news reports such as the one in Figure 3 and found an article in *MailOnline* (Waugh, 2012) that might just hold the key to her family's hair color riddle.

Assignment

A. Read the *MailOnline* article, "Riddle of Solomon solved: Scientists find South Sea islanders' blond hair didn't come from Europeans, but evolved separately": http://www.dailymail.co.uk/sciencetech/article-2139462/Riddle-Solomon-solved-Scientists-South-Sea-islanders-blond-hair-didnt-come-Europeans-evolved-separately.html

B. After reading the article, answer the following comprehension questions:
   i) According to the article, what is the frequency of people with (naturally) blond hair in the Solomon Islands/ Melanesia?
   ii) Prior to the study reported in the article, what were some commonly held ideas about the origin of blond hair in Melanesia? How do these ideas compare to the hypotheses that you and your class proposed in Part I, Question 3?
   iii) How did the study authors collect their data and samples in the field? What kind of data and samples did they collect?
   iv) What did the researchers do with the data they collected in the field? What did they do with the samples, and how did they analyze the results?
   v) What was the major finding from this study?

Questions

1. What do these data suggest about the origin of blond hair among Solomon Islanders? Which of the hypotheses you proposed in Question 3 of Part I do they support or contradict?
2. How could this information help Annika and Tane explain their daughter's dark hair color to the rest of the village?
3. Using symbols of your own choosing and the information thus far, assign genotypes to Annika, Tane, and their daughter. If the couple has another child, what hair color should they expect it to have?
4. In their original 2012 article, Eimear Kenny and colleagues estimated that in Melanesia (which includes the Solomon Islands) the frequency of the mutant ("blond hair") *TYRP1* allele is about 26%. Does this information, combined with what you learned from MailOnline article provide any evidence supporting the idea that Solomon Islanders might have a preference for mates with a given hair color? In other words, is there any evidence that mating is not random with respect to hair color? Use specific, quantitative data to support your explanation, and state any assumptions you are making.

Part III (C) – Geneticists to the Rescue

Figure 3. The title of a *Science News* article reporting the finding of Kenny and colleagues in 2012.

Annika was aware of the stir that her daughter's hair color was causing in the village. During her next trip to town she spent some time searching the Internet for information about the inheritance of hair color. She came across several news reports such as the one in Figure 3 and found a research article by Eimear Kenny and colleagues (2012) that might just hold the key to her family's hair color riddle. As she was not familiar with genomics and genome-wide association studies (GWAS), she also searched for information on how to read such studies, and found a helpful article (Bowcock, 2015) on the *Nature Education Scitable* website.

Assignment

A. Read the original article: Kenny, E.E., N.J. Timpson, M. Sikora, M.C. Yee, A. Moreno-Estrada, C. Eng, S. Huntsman, E.G. Burchard, M. Stoneking, C.D. Bustamante, and S. Myles. 2012. Melanesian blond hair is caused by an amino acid change in *TYRP1*. *Science* 336(6081):554.

   Like Annika, you should use the *Scitable* article (Bowcock, 2015) to help you interpret the data in the Kenny et al. paper: http://www.nature.com/scitable/nated/topicpage/finding-genes-for-common-diseases-using-gwas-132732965

B. After reading the articles, answer the following comprehension questions (which are targetted to the level at which you should understand the article):
   i) How frequent is the "blond hair" mutant allele, and how frequent is the "blond hair" phenotype in the Solomon Islands?
   ii) Draw a flow chart that shows how the entire study was conducted.
   iii) Draw a set of bar graphs, like the one shown in Figure 1 of the *Scitable* article (Bowcock, 2015), representing the respective frequencies of the mutant and wild-type *TYRP1* allele, and those of two alleles of a randomly chosen locus that is unrelated to hair color. Use "Dark-haired Solomon Islanders" and "Blond-haired Solomon Islanders" as your two populations (instead of "Healthy controls" and "Disease cases").
   iv) Describe the data shown in Figure 2A of the Kenny et al. (2012) paper. What do the dots represent? What is shown on the Y-axis? (*Note:* Saying "the observed (–logP)" is not sufficient; use your own words.) What is the grey horizontal line, and why is it relevant?
   v) At the molecular/biochemical level, what is the likely cause of the blond hair phenotype in the Solomon Islands? Provide evidence from the article and explain how it supports your answer.

Questions

1. What do the findings from the article suggest about the origin of blond hair among Solomon Islanders? Which of the hypotheses you proposed in Question 3 of Part I do they support or contradict?
2. How could this information help Annika and Tane explain their daughter's dark hair color to the rest of the village?
3. Using symbols of your own choosing and the information thus far, assign genotypes to Annika, Tane, and their daughter. If the couple has another child, what hair color should they expect it to have?
4. In Melanesia (which includes the Solomon Islands) it is estimated that about 5–10% of the native population has blond hair (Kenny et al., 2012; Norton et al., 2006). Do the findings reported by Kenny et al. (2012) provide any evidence supporting the idea that Solomon Islanders might have a preference for mates with a given hair color? In other words, is there any evidence that mating is not random with respect to hair color? Use specific, quantitative data to support your explanation, and state any assumptions you are making.

References

Bowcock, A.M. 2015. Finding genes for common diseases using GWAS. *Nature Education* 8(5):5.

Frost, P. 2006. European hair and eye color: A case of frequency-dependent sexual selection? *Evolution and Human Behavior* 27(2):85–103.

Kenny, E.E., N.J. Timpson, M. Sikora, M.C. Yee, A. Moreno-Estrada, C. Eng, S. Huntsman, E.G. Burchard, M. Stoneking, C.D. Bustamante, and S. Myles. 2012. Melanesian blond hair is caused by an amino acid change in *TYRP1*. *Science* 336(6081):554.

Norton, H.L., J.S. Friedlaender, D.A. Merriwether, G. Koki, C.S. Mgone, and M.D. Shriver. 2006. Skin and hair pigmentation variation in Island Melanesia. *Am J Phys Anthropol.* 130(2):254–268.

Waugh, R. 2012. Riddle of Solomon solved: Scientists find South Sea islanders' blond hair didn't come from Europeans, but evolved separately. *MailOnline*. Retrieved from: http://www.dailymail.co.uk/sciencetech/article-2139462/Riddle-Solomon-solved-Scientists-South-Sea-islanders-blond-hair-didnt-come-Europeans-evolved-separately.html.