Theodore G. Schurr, Ph.D.

For the last thirteen years, Theodore Schurr has characterized MTDNA and Y-Chromosome variation in the East Asian, Siberian and Native American populations. Among his current projects are studies of genetic diversity in modern Aleuts, indigenous Siberian peoples and Neolithic populations from Lake Baikal region. Schurr is currently an assistant professor in the department of anthropology and a consulting curator in the physical anthropology section of the Museum of Archeology and Anthropology at the University of Pennsylvania.

I know your specialty is molecular anthropology, could you explain what topics are researched in this field and what questions researchers in this field are trying to answer?

Molecular anthropology is an outgrowth of molecular biology, which is the study of human evolution, human biology, primates, and things of this sort, like human fossils. What we are doing is using DNA, or proteins in some case, to understand those same aspects of human history, human evolution, human variation, human migration patterns, and the genes that underlay human adaptation, such as adaptation to higher altitudes, skin color issue, pigmentation, lactase persistence (to be able to digest milk). In essence, we use genetic tools or molecular tools to understand human biology and evolution in a whole variety of different facets and aspects.

When you talk about DNA specimens, what kinds of DNA are you using, how are they obtained?

The DNA that we use, we use actually different parts of the DNA, we use Y-chromosomes to look at the history of men, we use mitochondrial DNA to study the history women (inherited from women's egg), and other genes that code enzymes that influence a whole variety of different aspects of our morphology. So the same is used for primates, the samples that are used, typically these days come from blood samples, others come from saliva or spit samples, or both, focal cell samples, from cheek scraping. We can also get samples from urine samples, feces samples, so basically any tissue that has any kinds of cellular material with it, can yield some amount of DNA for our genetic work.

Do you look for the differences between races, studying the patterns and then coming up with a theory of their origin?

In essences it is like that, but the genetics show that the notion of race is actually more complicated, that we are not so deeply subdivided, but the notions are the same, we have populations that distributed throughout the world and they all come from a common source in Africa, and the question is just as you posed it, how do people move across the world, how do the physiologies change as they move to different places, and then we try to relate that to archeological information, history and language, culture data, and other things of this sort, to provide the proper context for interpreting the patterns that we see in our DNA markers or DNA lineages.

So is specifically your research within this field? What questions are you specifically trying to answer?

One large question that I have been focusing on for the last couple of years and since I have been at Penn is the history of Native American populations. Where did they come from in Asia, how long ago did they come to the Americas, and how did they disperse across the continent of the Americas, and what happened once people were here, and the counterpart to that is also, is the history of Siberia. I have worked on that question for quite a number of years, trying to look at when people first arrived to Siberia, how they adapted to the area, and dispersed, up and down longitudinally. When you went you have glaciers melting and coming down, so the deal is sort of the dynamics of human occupation in Northern Eurasia. So those are the two big questions that I have been investigating for

a quite some time. I work in a number of places in the world, including places like Turkey and Argentina, I work with population from Melanesia, and actually from European groups, so I have a variety of studies at that are focusing on population in those areas, and some projects, which you may have questions about, that are more biomedically oriented. A projection on primate genetics and their history, and another that is more about bioarchelogy, where we are looking at ancient DNA from neo-lithic populations, recovered through archeological excavations.

So you are able to dig and find scraps of DNA and use that as a tool for analysis?

Yes, we actually extract the DNA out of human bones and teeth, in the buried skeletons, and use that DNA to look for the same kinds of markers and lineages, that are present in contemporary populations as to see how similar or different prehistoric people are to modern people, and aspects about their demography and kinship of this sort.

When you go to these archeological site, and extract DNA from bones and teeth, are you looking for DNA from different parts of the cell, in organelles such as the mitochondria? How are you able to locate that DNA, by visualization under a microscope? It's been a long time are the cells still intact?

Well, when you bury a body, your cells die, and the body does decompose, but a lot of times this process has been greatly slowed down because soil condition or the way the body has been buried in the casket or some kind of burial chamber, but the DNA that is most commonly used for this kind of work, is mitochondrial DNA, which is smaller, and tends to be less fragmented, and always appears at many, many copies per cells, so it's more abundant than nuclear DNA, and it's easier to find using molecular techniques. We can also look for Y-chromosome or nuclear markets with a greater or lesser degree of success, so they are single copies and so forth. At the cellular level, we don't pay much attention to the cell themselves, although we may use information about let's say collagen content of bone, since there tends to be a correlation between amount of collagen present and the degree of bone preservation, hence the probably success of extracting DNA out of those tissues. So there are other kinds of biological indicators that we can use to tell whether or not we should use the bones for successful DNA work.

So is there a link, between collagen and age, that there are more cross-linkage with age, are able to find the age of the bodies using collagen?

So the collagen that is found, or any source of carbon, can be used for C14 dating, so that is primary means of dating skeletons from 15 thousand year old.

So are you able to determine the age of the person when he/she dies?

That's a good question, and that information is ascertained from the skeleton, from size, gender, tooth immersion pattern, the wear on the bones. You can age skeletons using different osteological measures, or points of evaluation, you can use X-ray the bones to see the pivices, where the ends of the bones connect to the joints, to see how ossified they are, because that tells you that you are dealing with a mature person versus with someone with less ossified ones being a juvenile or 20 year old, so things like these are key to telling us the age of the person, not so much from the DNA work.

And in terms of Native American populations, what patterns have you specifically discovered amongst those populations?

Our work, as well as that by a number of other groups, has shown several major findings, and a lot of subtleties. The first American, the ancestors of native American populations, seem to have come here through a bridge, from the Siberias, from 15-20 thousand years ago around 16 to 18 thousand years ago. They probably came down around the coast of North, Northwest America, because there was a glacier sitting on top of the North America during the last glacier maximum, and right below the ice sheet, they dispersed very rapidly through the continents, using water crafts of some kind. We clearly see two major paternal lineages, these lineages nomenclatures are called C and Q, by historical naming, and there are four major mitochondrial maternal lineages, called A D C, D, and one other minor North American lineage called X. So we defined the lineages that are probably of the founding population's, and we think we found the number of founding types, that is, the types that define those branches of those that have come over. And now we are reconstructing, what happened largely when people moved across the land and settled there for quite some time. There became differences between North and South American populations, subtle differences between them, there is a difference between Amazonian and Veniatary, and the population came to North and South America because they probably split, with one going down West Coast one along the East coast. So these are starting to emerge with the use of genetics in concert with archeological data and other evidence, but there is some things like the timing, migration route, the dispersal pattern and the actual genetic composition of these populations that we now know from this kind of molecular anthropology.

So what forces drive the splitting of the lineages? Is it an environmental cause, like their body is adapting to

the environment, or are there random mutations that cause them to split?

This in fact is one of the questions that we are examining very closely now. Where it is selection or adaptation that is shaping the variation that we see present in the lineages or splitting of the branches or sub-branches, or whether it is more of a stochastic or random process of mutations. The genomes that we look at more closely, the mitochondria, and Y-chromosome, are haploid, one copy from mom or dad, they are much more subject to genetic drift, so increasing or decreasing in frequency just because of the relative success rate of women having daughters, or men having sons, or environment, or if a population size is shrinking or growing, and thing of this sort. So clearly these kinds of random processes are influencing what we see, that mutation is generating new branches. Now whether they survive or actually disappear due to adaption or selection that is the question that we are looking at very carefully and we are not entirely sure, and how much selection plays a role. Selection, may have played a role, but we don't know exactly how it did, so that is, at least for me, the focus of studies now, and that is the types of questions that studies are now focusing on.

Are there any current hypotheses on how natural selection forces have caused population variation?

Natural selection could be working on these populations, not on the genes that we are looking at, for example populations, if they are moving in to the Amazon, and they move into places that are tropical, where there are a lot kinds of parasites, and worms, so those could be the selective agents that could be shaping their adaptation. But we may not see that in some of the genes that we are looking at, and we need to look at other nuclear genes. It could be the climate is important, and not only perhaps for native American themselves but their ancestors in Siberia, such as cold adaptations that they are brought with them. Those are a couple of variables, sort of disease or epidemiological factors and things like climates, which really force people to shift subsistence patterns and live in different places, and those kind of changes may also have some impact on their adaptations.

Our theme for our next publication is about evolution, how does molecular anthropology fit into the frame working of studying evolution, does it support and provide current theories about human evolution?

Without evolutionary theory and evolutionary biology we won't have genetics, and all three are apart of the biological paradigm, and how we actually do our work, how we interpret data is about this force that change populations. In our field, there has been a lot of debate about human evolution, and where people came from, and how humans dispersed, so genetics is adding some new information to the picture that we before largely based on human fossils, and is now tending to come together in terms of theory about modern human origins as relatively recent compared to our hominid ancestors, some 200 thousand years ago, and then our species emerging and living in Africa for some time, before dispersing some 17th thousand years ago. So those kinds of data, the paleontology, archeological, and genetic data, are all telling a relatively similar story, which is quite exciting because 10 or 15 or 20 years ago, they didn't. Genetics and molecular anthropology were much newer, and we didn't have so much information, but now we some commonalities or similarities. So this is an evolutionary science, and it's fundamentally linked to our understanding of how DNA is replicated and how it changes through time, whether you are talking about non-human organisms or human beings. The one variable that we are trying to contend with though, which is a little bit different than other species, is the issue of human culture and how humans impact their environments, and changing the selective forces on them, how it impacts their bodies and their genes and so on. That is the more complicated part of what we do as anthropologist and molecular anthropologists, and it's extremely interesting and we are able to get some handle, some idea of how this is might have occurred and beginning to understand the interaction between biology and culture, for human populations over many thousands of years for our species, and we are interpreting the genetic variations in contemporary human groups.

So are there a lot of cooperation between biological anthropologist and those who study culture even more so than before?

Certainly, there are some domains within anthropology which are not so terribly interested in the evolutionary part of anthropology, those who are concerned with human behavior, primate behavior, and many who are interested in the emergence of culture and cultural groups, and emergence of language for example, they are curious about what the evolutionary side of the field has to say about when these processes, when people began speaking, the timing of these things, and how related we are to chimpanzees, or other mammalian species, and in another words, how far back does the human race extend in time for many thousands and millions of years, we do share features that are common with others in the natural world, but we are unique from them, so that in part, also what are trying to gain in looking back in time and doing this comparative study. Within anthropology in general, I think some of the work we are doing is pushing people to talk more to each other about our findings and about how you relate genetic information for example,

to other types of cultural behavior, linguistic behavior or general behavior, and nature and that is led to some very productive conversations, about who are humans, what is our human nature, how we relate to the rest of the world.

You mentioned before the biomedical projects that involve molecular anthropology, could you elaborate more on that?

Sure, DNA is DNA, it tells us a lot about our ancestry but it can also tell us something about our susceptibility to diseases that result from where we grew up and where our ancestors came from. It could actually be individual. Now we are starting more about the human genome, and the amount of variation that exist within humans today. And some of the questions we are interested in with regard to adaptation to, let say heart disease, hypertension, adaptation to high altitude, may also involve genes that are involved in certain kinds of disease processes, for example hemoglobin genes has been looked at very closely in a lot of species because of its viable role in providing oxygen for all our biological processes, in different species, and whether that was its role several thousands of years ago, but also when mutations occur in those genes in humans that cause various sorts of problems, various sorts of hemolytic disorders.

Like sickle cell?

Like sickle cell, thalassemias and things of that sort. So the genetics allow us to look at the aspects of history, and diversity, the emergence of genetic lineages, the dispersion of human groups, and in fact, when you have certain kinds of mutations, they can cause problems metabolically or physiologically in human populations. In the case of malaria, sickle cell anemia is very interesting, it's a classic case of biology anthropology, where you have clearly genetic implication. But also very importantly, you have information about human adaptation and subsistence transitions in Africa, where they go from hunter -gathers to agriculturalist, the change in the environment to allow mosquitoes to breed, and farms becoming the focus of mosquitoes and malarial parasites, and that producing enormous selection on the genome of humans. And the sickle cell anemia being one of several kinds of genetic adaptations, which allow people succeed, to produce and live, in malarial situations, despite the fact that they are also somewhat anemic as a consequence of bearing these kinds of mutations. That is one of examples of many other ways in which this evolutionary and molecular anthropology approach moves into the biomedical realm, to inform more clinically oriented type of research about evolutionary or population genetic questions and maybe bring together not just a new understanding of the disease, ways of thinking and treating of the disease, but reflects some evidence about human adaptation and variation.

About your research on campus, what specific things, techniques are done in your lab? How is your lab organized? Do you employ undergraduate students?

The laboratory is a fairly typical biology or genetics lab. We have equipment to do DNA sequencing, genotyping, DNA extractions, if we need to, we can do cloning, although we the ability to do a variety of molecular techniques, which could be used to analyze DNA, and genetic material in a non-anthropological way, the core facilities on campus, also give us a lot of access to a lot of equipment, we use for our own projects. So we have equipment, and the orientation to use certain kinds of markers systems preferentially, such as for mitochondrial or Y-chromosome, we use DNA, not to understand only about human variation, but also human biology. So people involved in the lab, there are post-doctoral and graduate students, and undergrads, and technicians, a variety of people, and students from different levels and enterprise, and generating genetic data for grants and papers that we write, and get training as a consequence of being there.

So it is basically a molecular genetics lab?

Yes, but it is also the interpretative framework, we are looking at data for anthropological content. And it's population genetics, it's phylogentics, looking at gene trees to analyze evolutionary processes, and using various kinds of statistics to evaluate aspects of diversity and selection and things of this sort, and to some extent bioinformatics, to be able to do data mining, and looking up genetic data for comparative studies. So those kind of things, also go along with the bench techniques used to get the genetic data that we need to evaluate.

So what made you became a molecular anthropologist, what is your educational background, and what got you on this path of being where you are?

So many of us, my cohort, of young molecular anthropologist have the same kind of story, you start out in zoology, or genetics like me, and then went to anthropology because there were opportunities to use genetic tools to understand aspects of human history. This field did not exist 20 years ago, we kind of emerged out of anthropological genetics that looked fingerprint, cranium features, looking at genetics features with a more of a morphological orientation, and what really when things took off was in 1985 with the invention of the PCR, polymerase chain reaction, and that opened the door to everything that we are doing right now, allowing significant explosion/ expansion of molecular anthropology of human and primate population genetics, with a very strong evolutionary focus. So I happened to be doing my undergraduate studies, and doing some other work in genetics labs, at that time, that field was

beginning to emerge, and I happened to be able to move into a lab where the first kinds of studies with mitochondria DNA and diseases were done, so that's how I went from zoology to genetics and molecular anthropology, so that wasn't atypical for people of that time. Now, there are various labs like mine, and people are trained in molecular anthropology. But people actually being trained within a specific subfield, that did not exist in previous decades.

What kind of students would you encourage to explore this field, to work in your lab? What kind of skills are needed to be successful in your field?

If an undergraduate student wanted to work in my lab, it would nice if they had some kind of lab experience, because there is a way of working in lab that is sort of different from working in other places, there is a routine repetitious quality to it, all of which need various specific sort of ways and accuracy and precision, those kind of skills are learnable and in fact we train people to have them, but some previous experience helps. I think aside from having good hands at the bench, one key attribute for someone working in this field is curiosity, clearly a strong interest in evolution and variation, the biological dimension of anthropology, more than just biology in general, and also having a slight quantitative bent, help to be able to work through all the data and statistics if a person is thinking of moving into the field. So those are the sorts of general characteristics that do help if a person is thinking about moving into this kind of field. And of course, if someone is moving out of anthropology, they have skills in oteonology, in primate behavior and can apple those backgrounds to answer the questions in molecular anthropology.

What classes are there on campus about molecular anthropology?

There are many courses human genetic and anthropology, I teach several courses including one that is called molecular anthropology. Student just have to keep their eyes open for this course. I offer it every other fall, and took up another course called anthological genetics which is our survey class looking at different approaches of looking at human variations. I teach a class on genetic applications today which is about reproductive technology, forensics, and looking genetics and its use today, so that is a third course that I teach. There may be others that I may teach in the future, about the people of Americas, which will then have some genetic component to it. The other classes have more have genetic analysis and actually some practical hands-on work, but one about Genetic application in Modern World, is more of a discussion course, or survey class in some sense.

-Interview by Jenny Lin