Who is a New Zealander?

Curious Minds project 2016

The Longest Journey: From Africa to Aotearoa

http://www.africatoaotearoa.otago.ac.nz/

Your story. Our story. The human story.

About the project

The Longest Journey; From Africa to Aotearoa project, carried out by Professor Lisa Matisoo-Smith, involved sampling the DNA of 2000 New Zealanders from 2013 through 2015 to explore the genetic make-up of New Zealand today in response to the question, "Who is a New Zealander?". [1].

Matisoo-Smith's group is also working with National Geographic's Genographic Project, trying to add the Pacific expansion to the global picture of human dispersal out of Africa. "This is what I think makes the Pacific such an incredibly exciting place to work. We've got settlement representing some of the first human dispersals out of Africa with the initial settlement of Australia and New Guinea some 45,000–50,000 years ago and we've also got the last major human dispersal which was the settlement of Polynesia, extending all the way to South America, so it's a wonderful place to be studying humans and human adaptations."

The Allan Wilson Centre also secured funding from the Ministry of Business' Innovation and Employment's Unlocking Curious Minds Fund to run a project entitled "Who am I and where do I come from?" The purpose of this project is to deliver a programme to engage young high school students in the project by telling them the amazing story of how a small band of humans left Africa 60,000 years ago, spread across the entire world, and finally journeyed here to Aotearoa – the longest and most dangerous leg of the human journey. The stories of our origins and different journeys are in our DNA.

One of the main focuses for this programme is the students telling their own personal stories, and that they feel that their story is just as important as any other New Zealanders. To do this, the research group are visiting secondary schools in Northland, Auckland, Bay of Plenty and Tairawhiti; talking to them about the human journey, how similar we are under the skin, the science of DNA; and videoing students telling their stories about who they are and where they have come from.

A challenging aspect about teaching this subject area is that it is constantly changing as new evidence is discovered; and if you go searching for information there is a huge body of knowledge. It is important to remember to use this context as an opportunity to have students think critically about models and evidence, and to look for overall trends and patterns.

Whilst there is a lot of very good material available already, this resource seeks to provide you with further ideas and activities that you might use with your classes.

Jean Allibone
Caroline Hepburn-Doole

April 2016

[1] http://www.allanwilsoncentre.ac.nz/massey/learning/departments/centres-research/allan-wilson-centre/past-events/past-events_home.cfm

Links to the New Zealand Curriculum

New Zealand schools deliver the New Zealand Curriculum (NZC) [2] which states a vision of the 21st Century citizen as confident, connected, actively involved and lifelong learners. Alongside the vision are sets of declared principles, including coherence and future focus; and values which include inquiry, curiosity, equity, integrity and respect.

The NZC identifies five key competencies required to realise this vision:

- Thinking
- Using language, symbols and text
- Managing self
- Relating to others
- Participating and contributing

These competencies apply to students at all curriculum levels and across all eight learning areas. Each learning area has a further set of achievement objectives and rationale.

The two most obvious learning areas that the Curious Minds project fits into are the Social Sciences and Science. In the senior school the projects' findings directly support the senior Biology curriculum and could be used as a context in. 'Who is a New Zealander?' could provide inspiration for a Science and Social Sciences integrated topic, or could be used for a wider, cross-curricula project that encompasses a broader range of curriculum areas.

Where you might be able to extend into other strands:

Health and Physical Education	Comparative anatomy and physiology to look at trends Personal identity
English	Static images Debate a point of view e.g. models of dispersal Creative writing Unlocking texts Speech
Mathematics and Statistics	Statistics and data Measurement Modelling activities e.g. Half Lives Linear modelling
Technology	Creating something for an early human using technology process Investigating ocean-going craft building techniques and materials
The Arts	Investigate dance/music of indigenous people throughout Pacific Production and use of different pigments and techniques used in drawing Tattoo designs throughout different peoples Cave art comparison at different sites
Learning languages	Investigate different languages – different maps of phonics FOXP2 gene Transmission of ideas – oral traditions/whakataukī

[2] http://nzcurriculum.tki.org.nz/The-New-Zealand-Curriculum,

Science

The Nature of Science (NOS) objectives are the overarching aims of the Science curriculum. These are the lens through which all science teaching and learning should occur.

Nature of Science

Level 5 and 6, students will:

Understanding about science

- Understand that scientists' investigations are informed by current scientific theories and aim to collect evidence that will be interpreted through processes of logical argument.

Investigating in science

- Develop and carry out more complex investigations, including using models.
- Show an increasing awareness of the complexity of working scientifically, including recognition of multiple variables.
- Begin to evaluate the suitability of the investigative methods chosen.

Communicating in science

- Use a wider range of science vocabulary, symbols, and conventions.
- Apply their understandings of science to evaluate both popular and scientific texts (including visual and numerical literacy).

Participating and contributing

- Develop an understanding of socio-scientific issues by gathering relevant scientific information in order to draw evidence-based conclusions and to take action where appropriate.

Living World

Evolution
Level 4

- Explore how the groups of living things we have in the world have changed over long periods of time and appreciate that some living things in New Zealand are quite different from living things in other areas of the world.

Evolution
Level 5

- Describe the basic processes by which genetic information is passed from one generation to the next.

Planet earth and beyond

Earth systems

- Investigate the composition, structure, and features of the geosphere, hydrosphere, and atmosphere.

Social Sciences

The social sciences learning area is about how societies work and how people can participate as critical, active, informed and responsible citizens. Contexts are drawn from the past, present and future, and from places within and beyond New Zealand.

Through the social sciences students develop the knowledge and skills to enable them to: better understand, participate in, and contribute to the local, national, and global communities in which they live and work; engage critically with societal issues; and evaluate the sustainability of alternative social, economic, political and environmental practices.

Students explore the unique bicultural nature of New Zealand society that derives from the Treaty of Waitangi. They learn about people, places, cultures, histories and the economic world, within and beyond New Zealand. They develop understandings about how societies are organised and function; and how the ways in which people and communities respond are shaped by different perspectives, values, and viewpoints. As they explore how others see themselves, students clarify their own identities in relation to their particular heritages and contexts.

Social Science

Level 5

Students will gain knowledge, skills and experience to:

- understand how cultural interaction impacts on cultures and societies;
- understand that people move between places which has consequences for the people and the places; and
- understand how the ideas and actions of people in the past have had a significant impact in shaping people's lives and identities in Aotearoa New Zealand's developing society

Level 6

Students will gain knowledge, skills and experience to:

- understand how the causes and consequences of past events are of significance to New Zealanders and shape the lives of people and society

Science

In the Senior School this context sits directly in the Biology strands, as much of the biological ideas behind how we got to New Zealand are assessed in the NCEA Year 13 Biology Achievement Standard 91606.

Living World

Level 7

Evolution

- Understand that DNA and the environment interact in gene expression.

Ecology and evolution

- Explain how the interaction between ecological factors and natural selection leads to genetic changes within populations.

Nature of Science

Level 7 & 8, students will:

Understanding about science

- Understand that scientists have an obligation to connect their new ideas to current and historical scientific knowledge and to present their findings for peer review and debate.

Investigating in science

- Develop and carry out investigations that extend their science knowledge, including developing their understanding of the relationship between investigations and scientific theories and models.

Communicating in science

- Use accepted science knowledge, vocabulary, symbols, and conventions when evaluating accounts of the natural world and consider the wider implications of the methods of communication and/or representation employed.

Participating and contributing

- Use relevant information to develop a coherent understanding of socio-scientific issues that concern them, to identify possible responses at both personal and societal levels.

The story of human evolution - Background ideas for teachers

We don't know everything about our own species— we keep learning more! Through studies of fossils, genetics, behaviour and biology of modern humans, we continue to learn about who we are.

In 1871, Charles Darwin suggested in his "The Descent of Man" book that modern humans evolved in Africa and shared a common ancestor with the great apes. At that time there were no early human fossils and no DNA evidence - the discovery of DNA was in the distant future. At the time there was a lot debate as creation was still the most popular and commonly accepted belief. Darwin suggested that humans and apes share many biological features which led him to hypothesize that a common ancestor must have existed. Beginning in the early 1900s, scientists went on to use fossil evidence to support this.

In April 1953, Watson and Crick published the exciting news of their discovery, a molecular structure of deoxyribose nucleic acid, DNA, based on all its known features - the double helix. Their model explained how DNA replicates and how hereditary information is coded on it.[3]

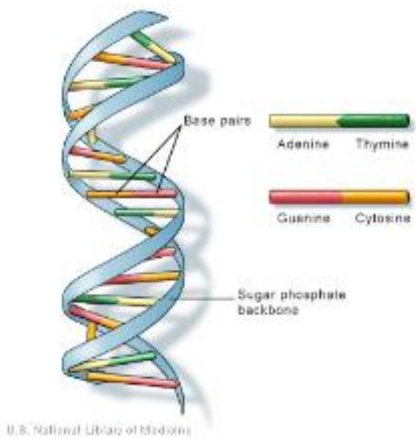
What is DNA?

DNA, deoxyribonucleic acid, is the hereditary material in almost all organisms. Nearly every cell in an organism has the same DNA. Most DNA is located in the cell nucleus, where it is called nuclear DNA; but a small amount of DNA can also be found in the mitochondria, mitochondrial DNA or mtDNA. The information in DNA is stored as a code made up of four chemical bases: adenine (A) cytosine (C) guanine (G) and thymine (T).

Human DNA is made up of about 3 billion bases, and more than 99 percent of those bases are the same in all people. The order, or sequence, of these bases determines the information available for building and maintaining an organism; similar to the way in which letters of the alphabet appear in a certain order to form words and sentences.

DNA bases pair up with each other, A with T and C with G, to form units called base pairs. Each base is also attached to a sugar molecule and a phosphate molecule. Together, a base, sugar, and phosphate are called a nucleotide. Nucleotides are arranged in two long strands that form a spiral called a double helix. The structure of the double helix is somewhat like a ladder, with the base pairs forming the ladder's rungs and the sugar and phosphate molecules forming the vertical sidepieces of the ladder.

An important property of DNA is that it can replicate, or make copies of itself. Each strand of DNA in the double helix can serve as a pattern for duplicating the sequence of bases. This is critical when cells divide because each new cell needs to have an exact copy of the DNA present in the old cell.



Credit: U.S. National Library of Medicine

[3] **A Structure for Deoxyribose Nucleic Acid.** Watson J.D. and Crick F.H.C. *Nature* **171**, 737-738 (1953)

Many of the early studies focused on the proteins produced by the DNA sequence. These proteins were studied to assess the genetic similarities between species - closely related species should have similar sequences; therefore resulting in similar proteins. The ability to sequence DNA was not possible until the 1970s and it was not until late in 1983 that it was really possible to obtain DNA from fossil specimens by polymerase chain reaction (PCR).

The first study of ancient DNA (aDNA) came in 1984, when Russ Higuchi and colleagues at Berkeley University reported that traces of DNA from a museum specimen of the Quagga not only remained in the specimen over 150 years after the death of the individual, but could be extracted and sequenced.[4]

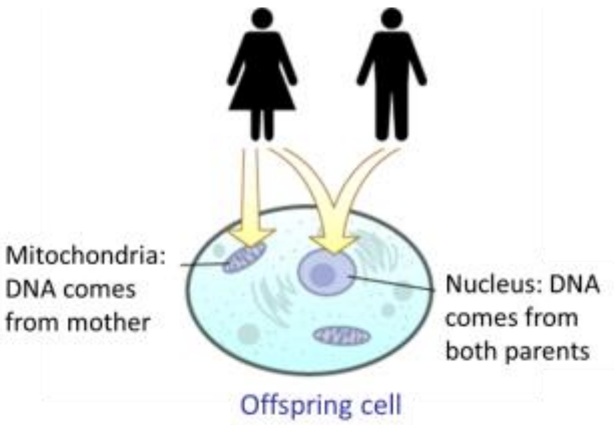
What is mitochondrial DNA?

Mitochondria are structures within cells responsible for converting the energy from food into a form that cells can use. Each cell contains hundreds to thousands of mitochondria which are located in the cytoplasm (the fluid that surrounds the nucleus).

The mitochondria have a small amount of their own DNA. This genetic material is known as mitochondrial DNA or mtDNA. In humans, mitochondrial DNA spans about 16,500 DNA building blocks (base pairs), representing a small fraction of the total DNA in cells.

Mitochondrial DNA contains 37 genes, all of which are essential for normal mitochondrial function. Thirteen of these genes provide instructions for making enzymes involved in energy production. The remaining genes provide instructions for making molecules called transfer RNAs (tRNAs) and ribosomal RNAs (rRNAs), which are chemical cousins of DNA. These types of RNA help assemble protein building blocks (amino acids) into functioning proteins.[5]

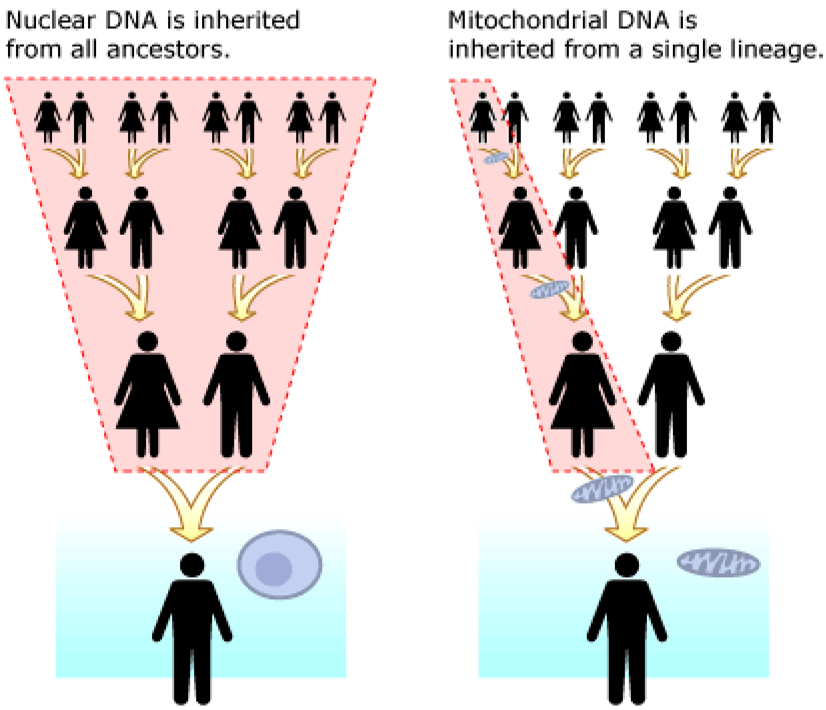
Mitochondria also play a role in several other cellular activities. For example, regulating the self-destruction of cells (apoptosis), and the production of substances such as cholesterol and heme - a component of hemoglobin, the molecule that carries oxygen in the blood.



[4] Higuchi R; Bowman B; Freiberger M; Ryder OA; Wilson AC (1984). "DNA sequences from the quagga, an extinct member of the horse family". Nature312 (5991): 282–4. Bibcode:1984 Natur.312..282H.doi:10.1038/312282a0. PMID 6504142.

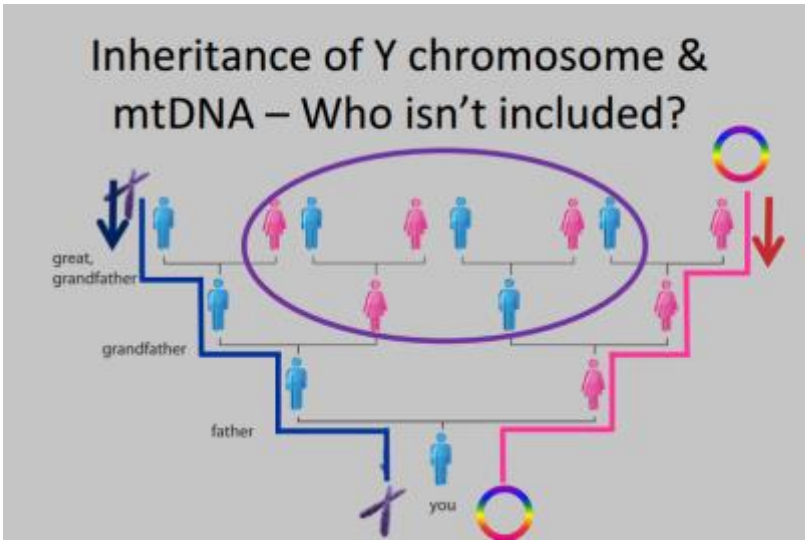
[5] https://ghr.nlm.nih.gov/

Mitochondria are only found in eggs and not in the head of a sperm, so we only get mitochondrial DNA from our mothers. Due to the fact that mitochondrial DNA is only passed down from female to female and doesn't get mixed with DNA from the father, changes in mitochondrial DNA over time can be easily traced back through a lineage.



University of California Museum of Paleontology's Understanding Science (http://www.understandingscience.org).

DNA sequences change or "mutate" over time, and these changes are passed from parent to child. As these changes build up, and populations migrate around the globe, each population will have some changes (which we refer to as "markers") that are specific to their area and others that reflect where that population came from. The more DNA markers two populations have in common, the more closely related those populations are likely to be. By comparing the number of DNA changes over time, and calibrating this with the fossil record, researchers can estimate how many years have passed since two populations split.



The improvement in modern technologies such as full sequencing of the genome, mtDNA and the Y chromosome has allowed a more accurate picture to be drawn. All of this information provides more information about the species and populations of people and how this genetic information flows. However, each part of it tells only part of the story.

A useful resource for genetics information at a junior level: **https://ghr.nlm.nih.gov/**

Evolutionary Tree Information

Modern humans (*Homo sapiens*) means 'wise man' in Latin and is the only surviving species of the genus *Homo*. Where we came from has been a topic of much debate, with fossils and DNA confirming that humans are one of more than 200 species belonging to the order of Primates and are part of the great ape family. Although we did *not* evolve from any of the apes living today, we share characteristics with chimpanzees, gorillas, and orangutans (the great apes) as well as other primates.

The use of genetic and fossil evidence has allowed us to determine that our closest living relative is in fact the chimpanzee. This means that we share a common ancestor but it does not mean that we evolved from chimpanzees. It was initially believed that humans split from their ape-like ancestors at least 20 million years ago. However, the work of Allan Wilson in 1967 showed that apes and humans diverged only 5-6 million years ago, making us much more closely related than previously thought.

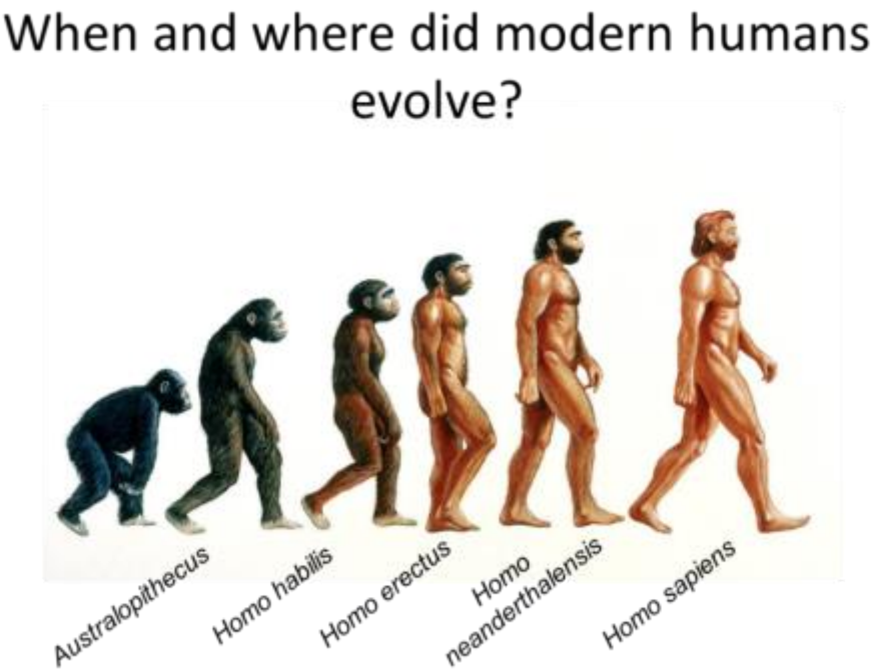
Scientists currently recognize 15 to 20 different species of early humans and hominins. Scientists often debate the identification and classification of particular species of early humans, and the factors influencing the evolution and extinction of each species. Many early human species -- certainly the majority of them – left no living descendants.

Fossil evidence tells us that our ape-like ancestors evolved in Africa into upright walking, tool-using and cultured hominins, spreading out across the globe. There have been many different hominid species in the past, but only one – *Homo sapiens* – has been ultimately successful. We are the only surviving branch of a diverse family tree. We are also considered to be a comparatively young species, as the fossil record indicates that the average lifespan of a mammal species is 10 million years.

Modern humans originated in Africa within the past 200,000 years and evolved from their most likely recent common ancestor, *Homo erectus*, which means 'upright man'. *H. erectus* is an extinct species of hominin that lived between 1.9 million and 135,000 years ago. The oldest fossils of modern humans were discovered in Herto, Ethiopia and are dated at about 160, 000 years old. [6]

Note:
Allan Wilson was born in Ngaruawahia and studied at the University of Otago. He then went on to further studies at the University of California, Berkeley, where he remained as a Professor until his death in 1991. He was one of the first people to use genetics to study how species are related to one another.

[8]

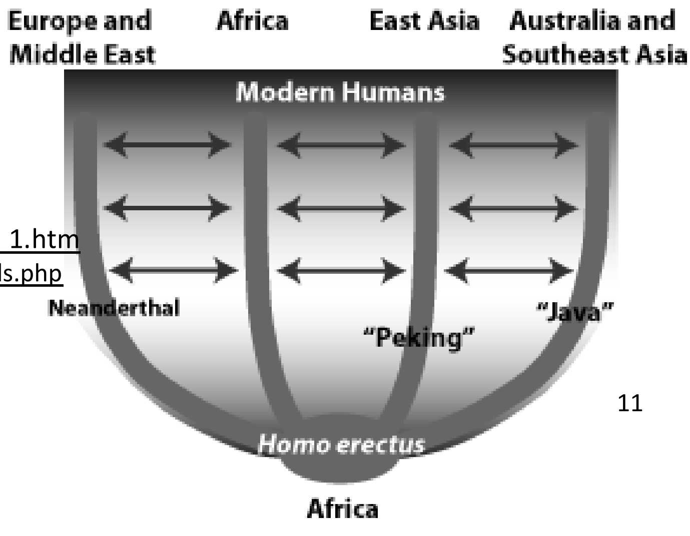


By 170,000 years ago there were hominids living in Europe, Africa and Asia. So where and when did modern humans evolve?

Did we evolve from *Homo erectus* separately in Asia, Africa and Europe?

We know *Homo erectus* migrated out of Africa about 1.8 million years ago, and that populations were already living in Europe and Asia. **The Regional Continuity Model (Multiregional Evolution Model)** suggests that modern human populations evolved from these ancient populations separately in Asia, Africa, and Europe with some interbreeding along the way. For example, modern Chinese are seen as having evolved from Chinese archaic humans and ultimately from Chinese *Homo erectus*.

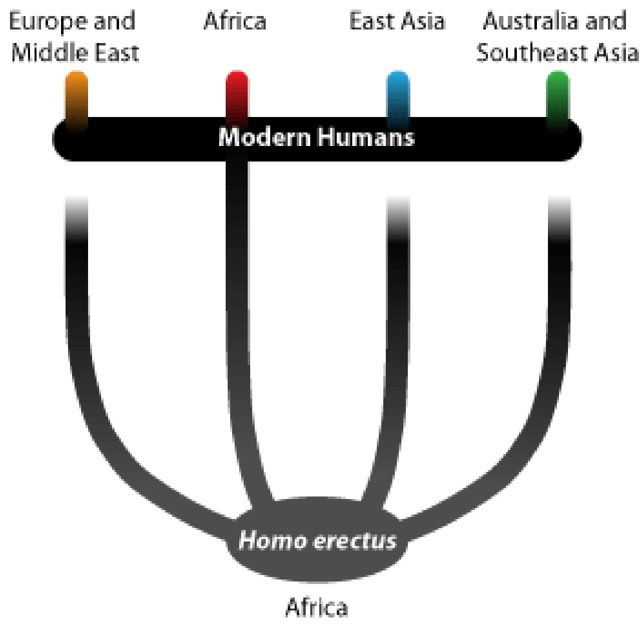
Supporters of this model believe that the common ancestor of all modern people was an early *Homo erectus* in Africa who lived at least 1.8 million years ago. There was contact between peoples of these distant areas which



[6] http://anthro.palomar.edu/hominid/australo_1.htm
[7] http://www.bradshawfoundation.com/herto_skulls.php

created gene flow and prevented reproductive isolation. This kept the human line a single species at any one time. However, regional varieties, or subspecies, of humans are expected to have existed.

The first Regional Continuity Model was favoured until the 1980s – modern humans evolved from *Homo erectus* separately in Asia, Africa and Europe.



Or did we evolve in Africa, and disperse recently (within the last 100,000 years) replacing any existing hominid populations?

The **Out of Africa or African Replacement Hypothesis** states that every living human being is descended from a small group in Africa, who then dispersed into the wider world displacing earlier forms such as Neanderthal. Early major proponents of this theory were led by Chris Stringer.

The Out-of-Africa theory was bolstered in the early 1990s by research on mitochondrial DNA studies by Allan Wilson and Rebecca Cann which suggested that all humans ultimately descended from one female lineage: the Mitochondrial Eve.

All other lines of humans that had descended from *Homo erectus* became extinct. Cann and Wilson showed that we can all trace our mtDNA back to one maternal lineage that existed in Africa around 200,000 years ago.

When you look at both the Replacement and the Regional Continuity Models there is difficulty accounting for all of the fossil and genetic data. What has emerged is a new hypothesis known as the **Assimilation (or Partial Replacement) Model.** It incorporates parts of both of the older models.

Gunter Brauer, of the University of Hamburg in Germany, proposes that the first modern humans did evolve in Africa; but when migrating into other regions they did not simply replace existing human populations. Instead, they interbred to a limited degree with late archaic humans resulting in hybrid populations. In Europe, for instance, the first modern humans appear in the archaeological record rather suddenly around 45-40,000 years ago. The abruptness of the appearance of these Cro-Magnon people could be explained by their migrating into the region from Africa via an eastern Mediterranean coastal route. They apparently shared Europe with Neanderthals for another 12,000 years or more. [7]

By studying mitochondrial DNA (mtDNA) sequences from people all over the world today, researchers have been able to build up a picture of how populations are related and where they are likely to have come from.

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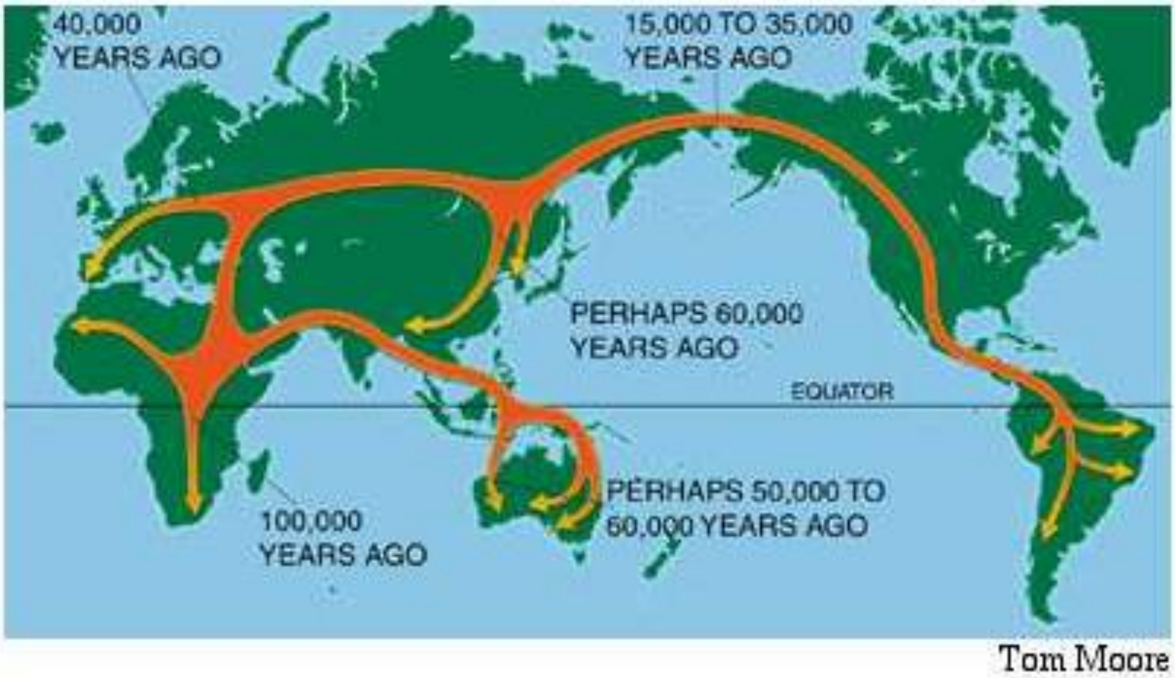


Mitochondrial markers show that around 65,000 years ago, women carrying one of the major African mtDNA lineages moved out of Africa. This lineage split into two branches – one moved east into South East Asia; and the other moved north into Europe and the near East, eventually reaching the far east and crossing the Bering Strait into the Americas. We know modern humans reached South East Asia and Australia around 50,000 years ago, and Europe around 40,000 years ago.

All modern-day Y chromosome lineages are descended from a single African lineage and began to diverge around 60,000 years ago. This fits with mtDNA evidence suggesting a dispersal out of Africa beginning around this time.

https://genographic.nationalgeographic.com/human-journey/

http://www.transpacificproject.com/index.php/genetic-research/

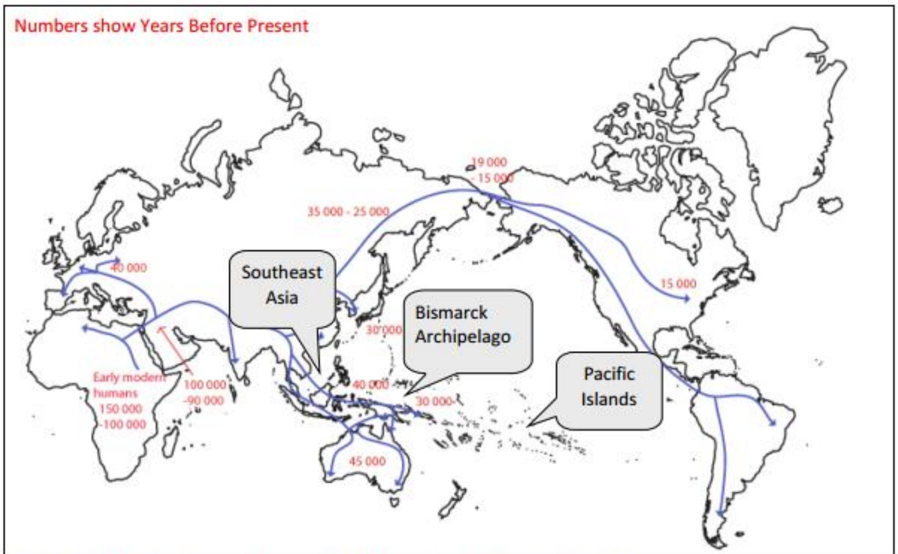


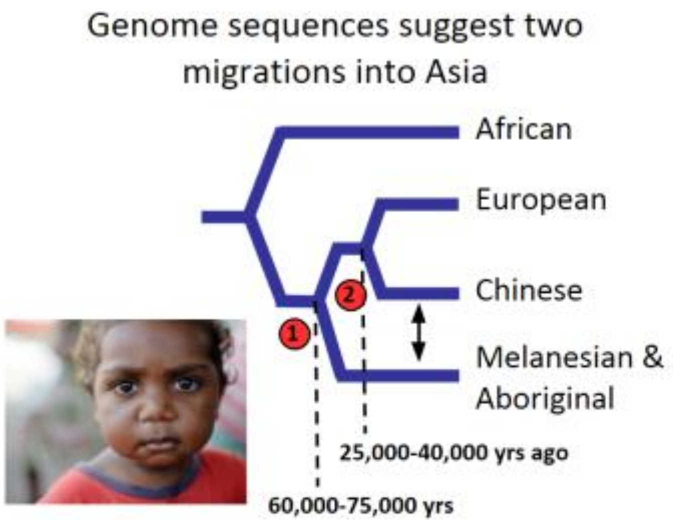
Figure 1. The dispersal of anatomically modern humans from Africa

In order to see all these previously “invisible” ancestors we need DNA sequences from all parts of the human genome. Advances in DNA sequencing technology mean that it is now possible to sequence whole human genomes far more quickly, and far more cheaply, than in the past. This has given researchers more power than ever before to trace who our ancestors were. Genomics is having a huge impact on the study of human evolution – many of the major recent discoveries about our origins have come from analysing genomes (both ancient and modern), rather than archaeology.

A study of the Australian Aboriginal genome, published in 2011, is a good example showing how these whole human genome sequences are refining our ideas about human dispersal. The Aboriginal genome was sequenced by a group of researchers from Denmark, China, US and Australia, and compared with genomes from European, Chinese, Melanesian and African individuals. Aborigines are known to be one of the oldest continuous populations outside Africa, with fossil evidence placing them in Australia as long ago as 50,000 years. The genome sequence enabled the researchers to more accurately date when Aboriginals diverged from other human lineages and to find out who their closest relatives are. The findings shed light not only on the history of Aborigines, but on the history of human dispersal into Asia. [8]

This study suggests that the ancestors of Melanesians and Australian Aboriginals split off from other non-African lineages quite early, around 60-75,000 years ago, moving down into South-East Asia. However, this dispersal event did not give rise to other Asian lineages, such as the Chinese. Instead, China was populated by a second wave of dispersal into Asia. The Chinese and European lineages diverged around 25-40,000 years ago. As the second wave of migrants entered Asia, they probably interbred with the descendants of the first dispersal.

This phylogenetic tree demonstrates how these groups are related. The ancestors of Melanesian and Aboriginal populations diverged from other non-African lineages early on ①, while the ancestors of Chinese and European populations diverged much later ②. This means that Chinese and European populations are more closely related to each other than they are to Melanesian and Aboriginal populations, although there has been some exchange of genetic material (black arrow) since the initial divergence.



[8] An Aboriginal Australian Genome Reveals Separate Human Dispersals into Asia
Morten Rasmussen, Eske Willerslev and colleagues, University of Copenhagen, Denmark

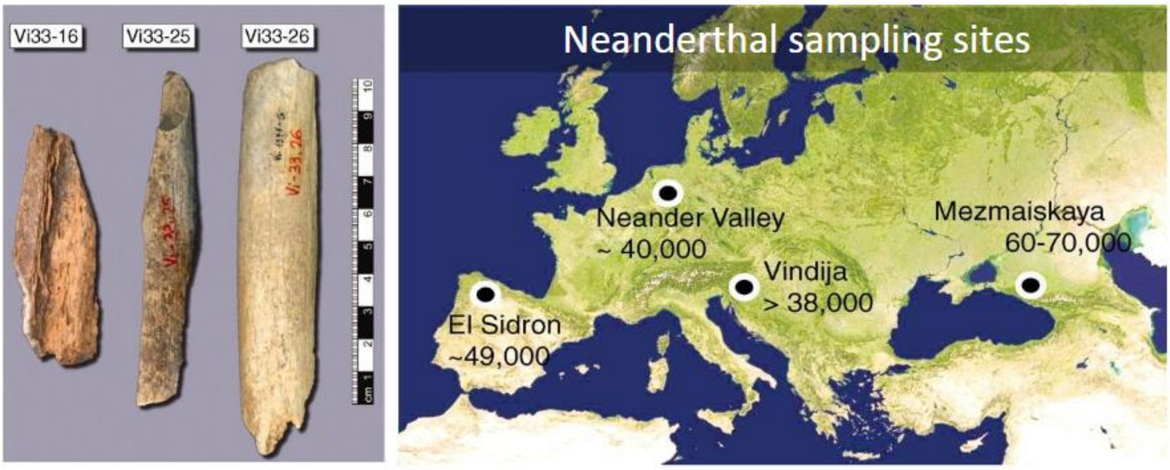
Genome sequences are also shedding light on our interactions with other ancient hominid lineages, such as the Neanderthals (*Homo neanderthalensis*). As modern humans spread across Europe and Asia they would have come into contact with the older hominid lineages already living there - descendants of *Homo erectus* - who first migrated out of Africa hundreds of thousands of years earlier.

In Europe, these populations became the Neanderthals – they were living in Europe at least 150,000 to 30,000 years ago. Neanderthals were stockier than modern humans with large brow ridges, a heavier frame and a barrell -shaped chest. They were similar to modern humans in some cultural aspects, such as burying their dead and use of clothing and jewellery.

The youngest Neanderthal fossils are from about 28,000 years ago – after that there are no traces of Neanderthals in the fossil record - suggesting that they were completely replaced by *Homo sapiens.* This is supported under the Out Of Africa Hypothesis - modern humans completely replacing Neanderthals. But Neanderthals and modern humans must have overlapped in parts of Europe over several thousand years, and yet the mitochondrial DNA data shows no evidence of interbreeding. Comparing the whole Neanderthal genome with our own is the only way to answer the interbreeding hypothesis for certain.

Researchers from the Max Planck Institute for Evolutionary Anthropology in Germany recently did just that. They were able to extract Neanderthal DNA from fossilised bones retrieved from four sites (shown on the map below, with approximate ages of the bones). Three bones from Vindija yielded suitable enough DNA to determine the entire Neanderthal genome sequence.

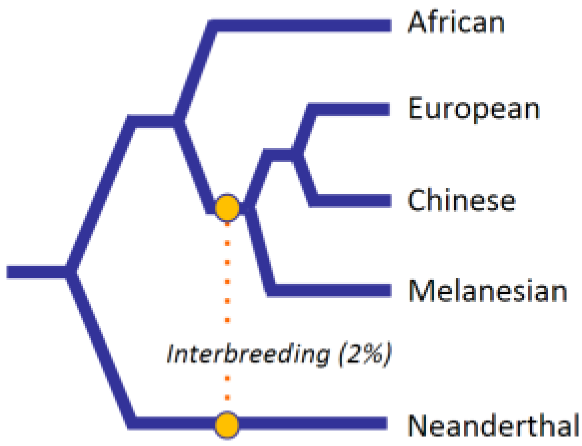
Fossilised bones provide a source of Neanderthal DNA



A draft sequence of the Neandertal genome
Svante Pääbo, Richard Green and colleagues, Max Planck Institute for Evolutionary Anthropology, Germany
Science 2010; Vol. 328 pages 710-722

To extract DNA from the fossilised bones, researchers used a drill to reduce the bone tissue to a powder, then used a series of chemical treatments to extract the DNA. Extreme care was taken to avoid contaminating the Neanderthal DNA with modern human DNA. Researchers worked in specially built “ancient DNA” labs (where no modern DNA work is carried out) and wore safety suits to avoid contamination. The DNA extracted was extremely fragmented but modern DNA sequencers can produce millions of short DNA sequences from these fragments, which researchers then piece back together using high performance computers.

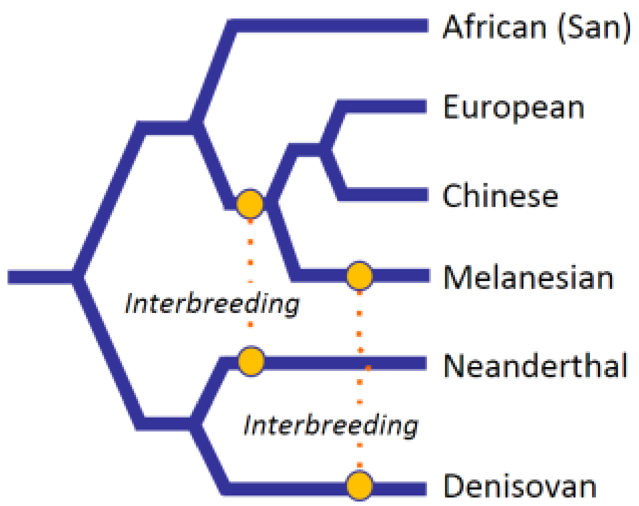
When the Neanderthal genome sequence was compared with modern human genome sequences something unexpected was found. Although overall the Neanderthal genome is significantly different from all modern humans, individuals from Europe and Asia (but not Africa) share around 2% of their DNA with Neanderthals. This suggests that European and Asian populations interbred with Neanderthals at some point in their history.



The Neanderthals may not have been the only ancient relatives that *Homo sapiens* encountered. In 2008 a fingerbone and a tooth were found in a cave, known as Denisova, located in the Altai Mountains, southern Siberia. They were initially thought to be Neanderthal but DNA sequencing showed that they were from a previously unknown lineage of early human that probably diverged from the Neanderthal lineage several hundred thousand years ago.

They were neither Neanderthal, nor modern human, so they were dubbed the “Denisovans”, after the region in which they were found. The ancestors of Denisovans and Neanderthals probably left Africa around 300,000 years ago then diverged into two groups – Neanderthals in Europe, and Denisovans in Asia.

The Denisovan genome was sequenced in 2010, and like the Neanderthal genome, there was some overlap with modern humans. Denisovan DNA shows up in the genes of modern Melanesians, Aboriginals and some indigenous South East Asian populations; suggesting interbreeding between these groups. This genetic evidence also suggests that Denisovans lived from Siberia down to South East Asia.



From the genetic evidence it appears that modern humans interbred with Neanderthals early on, probably in North Africa or the Middle East when they first moved out of Africa. An early dispersal then headed towards South-East Asia and Australia and interbred with Denisovans along the way. The second, later dispersal which produced the Chinese lineage didn't interbreed with Denisovans; and eventually *Homo sapiens* replaced, or assimilated, the older populations entirely.

The Out of Africa Hypothesis is still considered the best explanation for human origins, but these recent discoveries show that the picture is not as simple as was once thought. We are mostly of recent African origin, but with a small contribution from Neanderthal and Denisovan interbreeding.

However, the actual interbreeding events would have been very uncommon. A recent study modelled how much interbreeding must have happened for 2% Neanderthal DNA to have ended up in our genome. The researchers found that as few as 200 interbreeding events could leave us with about 1% Neanderthal DNA; 3% would only require about 430 matings. If you assume that the two groups overlapped for about 10,000 years; that works out to once every 25-50 years.

For information on the pacific migrations – see
http://lens.auckland.ac.nz/images/3/31/Pacific_Migration_Seminar_Paper.pdf

Proposed teaching sequence- Junior school

1. Introduce idea of species, as opposed to breed/race/population
    - Use dog species as a context (could introduce the kuri dog here)
    - Scaffold to human population

2. Personal Genealogy or use a well-known family/whanau tree
    - Could interview family members here if appropriate
    - How do you know what you know about recent family history?

3. NZ Herald 'We're all one family under the skin' (Professor Lisa Matisoo-Smith) (Appendix 1)
    - Introduce the project 'The Longest Journey, From Africa to Aotearoa' and the main concepts

4. What is DNA?
    - General structure and function
    - Idea of heritable code for both similarities and differences in a species; and between species

5. Advances in technology driving ideas about ancestry
    - Comparison of the original linear theory of evolution (ape to man), to modern branching tree of human evolution with a common ancestor
    - Emphasis on change in theories due to change in evidence: comparative anatomy and little fossil evidence; to larger numbers of fossils, improved dating techniques, DNA technologies etc

6. Dispersal concepts
   Using a modern context to scaffold to ancient dispersal e.g. Egyptian or Syrian refugees
    - Why disperse? (push factors)
    - In general, old ideas about hominin dispersal compared to new models and why these have changed - link to advances in technology, again, review and change being a normal part of good research

7. How do we know there was dispersal?
    - Fossil finds, including recent (*H. naledi, H. floresiensis, H. neanderthalensis,* Denisovans)
    - Biogeography
    - Cultural artefacts, including language
    - Commensal plant and animal species that are present in different areas because of human movement
    - DNA evidence - mtDNA, nuclear DNA, Y chromosome (*significant advances in technology* that have allowed for large shifts in thinking about human evolution)

8. Pacific migration - the last dispersal
    - How did we navigate in the Pacific? (particular emphasis on ancient Polynesian techniques)
    - What technology did we need?
    - What did we take with us?
    - What is the Pacific pattern of dispersal?
    - Why is this dispersal so much later?
    - What NZ specific evidence is there for this late dispersal (e.g. Wairau Bar artefacts, DNA evidence linked with commensal rats, pigs, dogs (kuri) and chickens)

Proposed teaching sequence - Senior school

In conjunction with normal teaching programme for Human Evolution context, having already taught relevant concepts about speciation and the occurrence of modern humans.

1. Introduction/Starter:
   NZ Herald 'We're all one family under the skin' (Professor Lisa Matisoo-Smith) (Appendix 1)
    - Introduce the project 'The Longest Journey, From Africa to Aotearoa' and the main concepts

2. Dispersal concepts
    - Why disperse? (push factors)
    - Who dispersed? (which species)
    - When did they disperse? (timeframe, ensure you look at what is happening in other parts of the globe at the same time e.g. Australia inhabited at the same time as the Neanderthals were in Europe)
    - Where did they disperse to?
    - How did they get there?

3. How do we know there was dispersal?
    - Fossil finds, including recent (*H. naledi, H. floresiensis, H. neanderthalensis,* Denisovans)
    - Biogeography
    - Cultural artefacts, including language
    - Commensal plant and animal species that are present in different areas because of human movement
    - DNA evidence - mtDNA, nuclear DNA, Y chromosome (*significant advances in technology* that have allowed for large shifts in thinking about human evolution)

4. Models/Theories/Hypotheses of dispersal
   Important to emphasise that these are constantly reviewed and amended as new evidence is found
    - Why are there currently 4 models?
      Link to a growing body of evidence, advances in DNA technology, increasing successes and accuracy with dating etc.
    - Out of Africa Model (African Replacement Model)
    - Multiregional Hypothesis
    - Hybridisation and Replacement Model
    - Assimilation Model

5. Pacific migration- the last dispersal
    - What are your personal experiences of this? (how did you come to be a New Zealander, what do you now about your own ancestry?)
    - How did we navigate in the Pacific? (particular emphasis on ancient Polynesian techniques)
    - What technology did we need?
    - What did we take with us?
    - What is the Pacific pattern of dispersal?
    - Why is this dispersal so much later?
    - What NZ specific evidence is there for this late dispersal (e.g. Wairau Bar artefacts, DNA evidence linked with commensal rats, pigs,(kuri) dogs and chickens)

A selection of useful resources for teaching this topic

The activities below are the possible learning objectives that might come out of looking at the context of *The Longest Journey: From Africa to Aotearoa*. They are intended as a smorgasbord; you pick and choose what activities will suit your students and the level at which you are teaching.

Introduction / background information

Suggested Year level	**What students will learn about (intended LO)**	**Context question(s)**	**Possible Learning Experiences**	**Resource details**
9/10	The evidence for showing genetic relatedness.	How are we all the same under the skin?	Read article (Appendix 1) We are all one family under the skin. New ideas/words that you need to know more about	Full article below Appendix 1 or http://www.nzherald.co.nz/opinion/news/article.cfm?c_id=466&objectid=11383731 Write words or ideas on post-it's that they are unsure of as they read.
13			Summarise main ideas in small groups Focus Qs - Main ideas Anything we don't understand? Why are these research projects important? What is the purpose of the project?	
9/10/13			Watch clip about Fresh insights into kiwi bloodlines - TVOne interview of Governor-General, Sir Jerry Mateparae (2014)	https://www.tvnz.co.nz/one-news/new-zealand/science-gives-fresh-insight-into-kiwi-bloodlines-6065948

Suggested Year level	What students will learn about (intended LO)	Context question(s)	Possible Learning Experiences	Resource details
9/10	Recognise that many people have a limited knowledge of their heritage	How far back do we know about our own heritage? How do we know what we know?	Investigate your own genealogy Investigate a well-known family tree Look at pictures of people and take note of what you could know about the person's heritage by looking at their pictures. (Appendix 2)	Brainstorm own knowledge of family tree and general heritage. Could also set as family research and interview task (it is important to consider any possible issues of sensitivity here) Discuss how records are kept: oral tradition, tattoos, carvings, drawings, births and deaths lists, census, family bibles, myths and legends etc. Family tree of immediate/extended family/whanau; or use pre-prepared: e.g. European Royal Family http://www.usefulcharts.com/european-royal-family-tree/ http://www.britroyals.com/windsor.htm e.g. Whakapapa of Makereti Papakura http://whenuaviz.landcareresearch.co.nz/place/75771 e.g. Ngato Naho https://ngatinahotrust.wordpress.com/2010/11/15/whakapapa-ngati-naho/ Victoria University info about Kupe and Rarotongan/Samoan connection http://nzetc.victoria.ac.nz/tm/scholarly/tei-SmiHawa-t1-body-d7-d11.html Nat Geo Human Genome Introduction: Beyond Genealogy, Spencer Wells (2.14) https://www.youtube.com/watch?v=bI54bPKsF7E

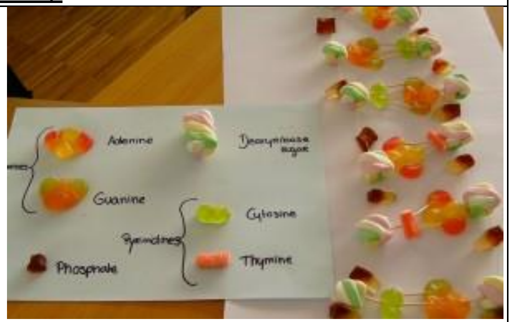
Ancient DNA

The focus here is understanding how we use information from morphology, physiology, mtDNA, nuclear DNA, and Y chromosomes to give us information about our evolution. It is important to realise that no one technology provides us with a complete picture - it only tells a part of the story. The information we have used over time has altered as technology has advanced and more fossil remains are found.

Suggested Year level	**What students will learn about (intended LO)**	**Context question(s)**	**Possible Learning Experiences**	**Useful Resource details**
9/10	Understand the concept of geological time and how recently modern humans appear in this time scale Recognise that what we know of our own genealogies is limited and short when compared to this.	Where do humans fit in relation to the dinosaurs and what came after them?	Make a scale timeline Use an interactive timeline	General activities including maps of time and games, how fossils are made etc. https://www.pinterest.com/mjkrech/teaching-geologic-history/ Timeline to put cards and/or objects on. Could also be made with rope/fishing line and hung in classroom; or toilet paper down a corridor https://www.educationaltoysplanet.com/blog/geological-timeline-even-preschoolers-can-learn-it-with-this-fun-activity/ Introduction to molecular genealogy http://learn.genetics.utah.edu/content/chromosomes/molgen/ Hanging spiral timeline http://www.science.edu.sg/resources/Pages/TitansofthePastHands-onActivities.aspx Football field map of time http://slideplayer.com/slide/4160588/ How did we get here? University of NSW - short chapter clips about Human evolution - need to cut and paste this URL into your browser http://splash.abc.net.au/home?hc_location=ufi#!/digibook/1905662/human-evolution-how-did-we-get-here https://www.youtube.com/watch?v=lqq6ihudBYU Range of activities with downloadable resources http://www.indiana.edu/~ensiweb/teach.fs.html
13		Where do modern humans fit in relation to the other hominins and primates? Why isn't hominin evolution linear?	Make a time scale that includes other hominins Use an interactive timeline that includes other hominins	

Suggested Year level	What students will learn about (intended LO)	Context question(s)	Possible Learning Experiences	Useful Resource details
				Evolution of earth in a minute (YouTube 1.11) https://www.youtube.com/watch?v=HGTh-vcBLJs History of the Earth in 5 ½ minutes (YouTube 5.25) Need to be careful about 'Adapt or Die' statement - teleology - clarify that it would be Natural Selection of 'most fit' from variation in the species) https://www.youtube.com/watch?v=8qnnoePeHlk
9/10/13	Recognise that evidence supporting modern human evolution was originally based only on fossil finds, and we still use these morphological clues to place new fossils Understand that technological advances have improved fossil dating methods	How are fossils formed/dated? How are fossils put into a timeline using comparative analogy? What other (non-DNA) evidence is used to date fossils?	Arrange strata into order and date the fossils. Use anatomical clues to place a mystery fossil. Investigate isotope half-lives. Discuss what and how other evidence could be useful- e.g. dating of artefacts found with hominin remains - middens, hearths, pollen, seeds, pigments, culture related objects.	Human Origins: Evidence of Human Evolution video Dr Potts https://www.youtube.com/watch?v=RQ7VUZHwbEk Basic activity about strata http://www.amnh.org/explore/curriculum-collections/dinosaurs-activities-and-lesson-plans/solve-a-sedimentary-layers-puzzle Cast and mould fossil formation http://www.classzone.com/books/earth_science/terc/content/visualizations/es2901/es2901page01.cfm?chapter_no=29 General overview using museum exhibits http://www.nhm.ac.uk/discover/the-origin-of-our-species.html Interactive click and drag skull id activity https://www.classzone.com/books/hs/ca/sc/bio_07/virtual_labs/virtualLabs.html Fossil craniums activity with pdf http://www.indiana.edu/~ensiweb/lessons/homskull.html Interactive timeline http://www.pbs.org/wgbh/evolution/humans/humankind/index.html

Suggested Year level	What students will learn about (intended LO)	Context question(s)	Possible Learning Experiences	Useful Resource details
				Riddle of the bones http://www.pbslearningmedia.org/resource/tdc02.sci.life.evo.riddlebones/riddle-of-the-bones/ New fossils indicate Early Branching of Human Family Tree, The New York Times 2012. Good link between evidence driving theory and how this will change with more evidence http://www.nytimes.com/2012/08/09/science/new-fossils-indicate-offshoots-in-human-family-tree.html The Human family Tree has become a bush with many branches, The New York Times 2007. Article about recent fossil finds and their importance http://www.nytimes.com/2007/06/26/science/26ance.html Timeline of World History: Pre-History – Meso –America - Silliman University. History 24B. Prof. Pamate (YouTube 10.34) https://www.youtube.com/watch?v=BHbJ1Wv9zsw&ebc=ANyPxKr1KhA7peSjGzAe2UvRDCTtwoAZJSxqAb2gmvGLRWH4T3-LpVpx7BWSq5AUUqqjsv-YgqimoBjAmkOYHwEknFmG2K0p1g Lee Berger talking about discovering *H. naledi* (YouTube 9.30) https://www.youtube.com/watch?v=vegzmFbHMeU Smithsonian activities site, including mystery skull interactive activity- very good overview of context http://humanorigins.si.edu/evidence/human-fossils/species Dating fossil m and m activity, isotope half life http://www.nuclearconnect.org/in-the-classroom/for-teachers/half-life-of-paper-mms-pennies-or-puzzle-pieces

Suggested Year level	What students will learn about (intended LO)	Context question(s)	Possible Learning Experiences	Useful Resource details
				Radiometric dating using beads http://www.acad.carleton.edu/curricular/BIOL/classes/bio302/pages/Half-life.html Dating using class as a fossil http://www.acad.carleton.edu/curricular/BIOL/classes/bio302/pages/ClassFossil.html Who's on first-relative dating activity http://www.ucmp.berkeley.edu/fosrec/BarBar.html Packrat middens http://sbsc.wr.usgs.gov/cprs/research/projects/global_change/middens.asp Article including use of linguistics http://www.smithsonianmag.com/science-nature/how-to-retrace-early-human-migrations-50762656/?no-ist General ideas and good overview of ways of dating slide #51 onwards http://slideplayer.com/slide/1588363/
9/10	Understand that advances in biotechnology have provided DNA evidence that have supported and changed the	What is DNA? Why is DNA useful for this project? How is DNA used to find out where my	Making DNA Structure activities. Comparing basic sequences to look for similarities and differences.	*Make DNA Lolly stands* 

<table>
<tr><th>Suggested Year level</th><th>What students will learn about (intended LO)</th><th>Context question(s)</th><th>Possible Learning Experiences</th><th>Useful Resource details</th></tr>
<tr><td></td><td>theory of human evolution</td><td>ancestors came from?

How is DNA used to decide what a fossil is, and how old it is?</td><td></td><td rowspan="2">Make DNA cocktails
https://www.youtube.com/watch?v=rESHv7d7O88

DNA Structure Revision:
http://www.google.co.nz/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=0ahUKEwih_sHGw5vMAhWGlJQKHXNCDxEQFgghMAE&url=http%3A%2F%2Fwww.alder.k12.oh.us%2Fuserfiles%2F251%2FClasses%2F2831%2Fdnamodelpartsforyourpresentation.pdf&usg=AFQjCNFurigDhIP8vgQy1meZBFF7y7BR3Q&bvm=bv.119745492,d.dGo

http://www.google.co.nz/url?sa=t&rct=j&q=&esrc=s&source=web&cd=11&cad=rja&uact=8&ved=0ahUKEwi3gIiWxJvMAhWBzpQKHWXRCZUQFghAMAo&url=http%3A%2F%2Fwww.coventryschools.org%2FDownloads%2Fmake%2520a%2520model%2520dna.pdf&usg=AFQjCNGNkUv8Xsha0Ws-_NvWRA9GCkRCzw

http://www.csiro.au/en/Education/DIY-science/Biology/DNA-model

Mutation and Haplotypes
http://learn.genetics.utah.edu/content/variation/haplotype/

Why DNA is useful for this project:
‘Breaking the Code’ clip (2.01)
https://genographic.nationalgeographic.com/science-behind/

Are we really 99% chimp?
https://www.youtube.com/watch?v=IbY122CSC5w</td></tr>
<tr><td>13</td><td></td><td>What is the human genome?

How is DNA used to decide what a fossil is, and how old it is?

How are nuclear and mtDNA used to find out where my ancestors came from?</td><td>Review DNA Structure and function.

Compare information and articles to understand DNA evidence-types and what it supports.

Break into groups to research different types of evidence for dispersal and feedback to the group.

Dating game for hominins- research each, then ask questions to determining if mating is possible</td></tr>
</table>

Suggested Year level	What students will learn about (intended LO)	Context question(s)	Possible Learning Experiences	Useful Resource details
				How is DNA used to find out where my ancestors came from? 'The Keys to Discovery' clip (2.48) https://genographic.nationalgeographic.com/science-behind/ What is a genome? – these could be cut into strips for students to organise into a graphic in their books http://www.yourgenome.org/facts/what-is-a-genome Freak Genomics introductory activity http://www.pbs.org/wnet/humanspark/lessons/freak-genomics/lesson-activities/?p=500 Y chromosome info to support dispersal map http://voices.nationalgeographic.com/2014/12/03/new-genographic-y-chromosome-tree/ Some mapped mutations http://kelsocartography.com/blog/?p=1811 Going where Darwin feared to tread (Washington Post 2009). Includes FOXP2 and MYH16 genes and other e.gs of Natural Selection creating genetic differences in the human population http://www.washingtonpost.com/wp-dyn/content/article/2009/02/11/AR2009021104244_5.html?sid=ST2009021200670 *How is DNA used to decide what a fossil is, and how old it is?* https://www.newscientist.com/article/dn22359-dnas-half-life-identified-using-fossil-bones/ National Geographic Education resources related to Genographic project mapping of dispersal

Suggested Year level	What students will learn about (intended LO)	Context question(s)	Possible Learning Experiences	Useful Resource details
				http://education.nationalgeographic.org/genographic/ https://bioscience.oxfordjournals.org/content/49/2/98.full Linking human evolution with bacteria, viruses etc. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1796772/

Dispersal/Recent finds

Evaluate information to work out who migrated where, when and why; and recognise how recent finds have altered what are considered the current views about human evolution. It is important to realise that this is constantly changing, and that this provides us with the opportunity to explore these models and ideas.

Some other aspects to be aware of: modern humans were in Australia at the same time Neanderthals were in Europe. The Pacific then had the last wave of human settlement to NZ about 800 years ago. It is also important to view the islands as the Pacific's highways. (See graphic in appendix 7). Trading routes were well established in the Pacific.

Take care with the use of the term migration rather than dispersal – migration is normally a return trip whereas dispersal is the spreading of a population.

Suggested Year level	**What students will learn about (intended LO)**	**Context question(s)**	**Possible Learning Experiences**	**Useful Resource details**
9/10/13	Reasons that populations emigrate in relation to niche and competition	Why do people emigrate? Where did hominins come from and where did they disperse to? Who did they meet along the way?	Start with a current refugee event and discuss why large groups of people may leave their country e.g. Egyptian, Syrian refugees etc. Scaffold to ancient hominin dispersals e.g. why would you disperse from your range 60,000 years ago? Track hominin dispersal onto world map using general dispersal routes or haplotype groups. Use a	*Current event resources:* Push and pull factors in a modern context (focus on 'push' as more relevant to ancient dispersal events) http://www.bbc.co.uk/schools/gcsebitesize/geography/migration/migration_trends_rev1.shtml https://www.embraceni.org/migration/why-do-people-migrate/ Syrian refugee crisis article and map http://www.businessinsider.com.au/map-of-europe-refugee-crisis-2015-9?r=US&IR=T https://www.google.co.nz/search?q=syria&safe=strict&espv=2&biw=1366&bih=667&source=lnms&tbm=isch&sa=X&ved=0ahUKEwj--dPX55vMAhVi3KYKHTWNAOwQ_AUIBygC#safe=strict&tbm=isch&q=syria+europe&imgrc=SLhVztLSOkL05M%3A https://www.google.co.nz/search?q=syria&safe=strict&espv=2&biw=1366

Suggested Year level	What students will learn about (intended LO)	Context question(s)	Possible Learning Experiences	Useful Resource details
			large world map and either use pins or pictures to show where different hominins have been found. Discuss what and how other evidence has been used e.g. dating of artefacts found with hominin remains- middens, hearths, pollen, seeds, pigments, culture related objects, animals. Jigsaw activity where students investigate parts of the journey and report back to the class. Introduce the other Homo species that Homo sapiens may have meet on their journey; *Homo neanderthalesis*, *Homo floresiensis*, *Homo erectus*, Denisovans.	&bih=667&source=lnms&tbm=isch&sa=X&ved=0ahUKEwj--dPX55vMAhVi3KYKHTWNAOwQ_AUIBygC#safe=strict&tbm=isch&q=syria+europe&imgrc=WcaynYUYgNTvlM%3A Overview of general factors related to migration and other links http://www.google.co.nz/url?sa=t&rct=j&q=&esrc=s&source=web&cd=5&cad=rja&uact=8&ved=0ahUKEwiKxsnX5pvMAhWB36YKHU6fCtUQFggxMAQ&url=http%3A%2F%2Fwww.nationalgeographic.com%2Fxpeditions%2Flessons%2F09%2Fg68%2Fmigrationguidestudent.pdf&usg=AFQjCNHWFioqDRx_4pdoNnVY9JPtuUBgMg&bvm=bv.119745492,d.dGY (migrationguidestudent.pdf) *Scaffold resources:* http://education.nationalgeographic.org/activity/migration-around-world/ *Hominin dispersal* Human dispersal detective activity http://education.nationalgeographic.org/activity/clues-to-human-migration/ Animated clip of dispersal https://www.youtube.com/watch?v=CJdT6QcSbQ0 Genographic dispersal map https://genographic.nationalgeographic.com/human-journey/ 2D Interactive http://www.hhmi.org/biointeractive/using-dna-trace-human-migration

Suggested Year level	What students will learn about (intended LO)	Context question(s)	Possible Learning Experiences	Useful Resource details
			Place pictures or pins on a map which show where fossils and DNA have been found. For Neanderthals, Denisovans and modern humans. How have these Hominin ancestors contributed to modern human genome? Look at a profile from the Genographic project and/or your teacher's profile. Look at Appendix 7 What impact will *Homo naledi* have on the modern family tree? Who is *Homo naledi*? When was it found? How is it different from other hominins? How might this species change the human family tree?	Interactive map https://www.dnalc.org/view/15892-Human-migrations-map-interactive-2D-animation.html Overview and link to coastal routes http://media.hhmi.org/biointeractive/click/Origins/17.html General article https://bioscience.oxfordjournals.org/content/49/2/98.full General article with good links e.g. Human Genome mitomap http://www.actionbioscience.org/evolution/ingman.html Journey of man 1 hr 53 min (long video by Spencer Wells) https://www.youtube.com/watch?v=-dDXIX-y6aY Appendix 6 comparative charts. http://www.livescience.com/topics/human-origins/ The Genographic project; Why am I Denisovan? https://genographic.nationalgeographic.com/denisovan/ The Genographic project; Why am I Neanderthal? https://genographic.nationalgeographic.com/neanderthal/ Fossil information http://www.efossils.org/

Suggested Year level	What students will learn about (intended LO)	Context question(s)	Possible Learning Experiences	Useful Resource details
				Hobbits On Flores, Indonesia video http://humanorigins.si.edu/multimedia/videos/hobbits-flores-indonesia The Hobbit: When scientists disagree about the evidence http://serc.carleton.edu/sp/process_of_science/examples/hobbit.html http://serc.carleton.edu/sp/process_of_science/examples/hobbit.html http://wondergressive.com/real-life-hobbits-discovered/ http://faculty.piercecollege.edu/steinp/docs/Paper%203.pdf http://www.livescience.com/29100-homo-floresiensis-hobbit-facts.html *H. naledi* articles and clips: Is this the oldest human? (*H. naledi*) http://www.dailymail.co.uk/sciencetech/article-3228991/New-species-ancient-human-discovered-Fossilised-remains-15-bodies-unearthed-South-African-cave.html?ito=social-facebook http://www.smh.com.au/technology/sci-tech/mapping-the-dna-inheritance-from-neanderthal-and-denisovan-ancestors-20160329-gnsvv0.html http://www.smithsonianmag.com/science-nature/what-makes-fossil-member-human-family-tree-180956572/ Appendix 9 and 10 – a model Genographic project profile – male and female

Suggested Year level	What students will learn about (intended LO)	Context question(s)	Possible Learning Experiences	Useful Resource details
9/10/13	What was required to travel great distances?	How did hominins disperse? What other resources did hominins need to disperse?	Brainstorm ideas in modern context e.g. what allows us to emigrate? Scaffold what resources/technologies would have been available at different points in time	Worksheet on human migration patterns https://school.bighistoryproject.com/media/khan/Worksheet_2014_CU6-3_HumanMigrationPatterns_Teacher.pdf Why humans left their African homeland 80,000 years ago to colonize the world http://www.smithsonianmag.com/history/the-great-human-migration-13561/?cmd=ChdjYS1wdWItMjY0NDQyNTI0NTE5MDk0Nw&page=1 Worksheets relating to use of fire and changes in tool culture: http://www.google.co.nz/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&cad=rja&uact=8&ved=0ahUKEwihoZv2o57MAhXB2KYKHUcJApIQFggtMAM&url=http%3A%2F%2Fwww.lee.k12.nc.us%2Fcms%2Flib03%2FNC01001912%2FCentricity%2FDomain%2F448%2FLESSON%2520PLANS%2520%2520RISE%2520OF%2520EARLY%2520HUMANS%2520%2520CHAPTERONE.pdf&usg=AFQjCNHUHzjlVFCFgFoCOc7Q-XVVibwdsA&bvm=bv.119745492,d.dGY
13	Models of Dispersal	What did we used to think? Why are there different theories about dispersal? What are the different theories?	Look at different images showing human evolution. Compare the descent of man type image with a modern phylogeny. If you can get an image on a cup or similar this might be useful. Many cartoons also online	Linear evolution image- Appendix 3 Common ancestor activity ts_origins.pdf – may need to log in to DNA interactive (www.dnai.org) for some of the content The Mystery of the Skulls: What Can Old Bones Tell Us about Hominin Evolution? Mike Darwin Yerky, Carolyn J. Wilczynski *The American Biology Teacher*, Vol. 76 No. 2, February 2014; (pp. 109-117) DOI: 10.1525/abt.2014.76.2.7 http://abt.ucpress.edu/content/76/2/19

Suggested Year level	What students will learn about (intended LO)	Context question(s)	Possible Learning Experiences	Useful Resource details
			Use with focus questions: What does the image tell you? Is this accurate? How are the two images different? Jigsaw activity: Break the class into a group for each current hypothesis. For each hypothesis outline:What is the hypothesis? Who proposed it? When did the dispersal occur? When was the hypothesis produced? What evidence supports the hypothesis? Is there any information that disproves/conflicts with the hypothesis?	Graphic about DNA links of recent finds, Appendix 5 Appendix 8 Testing Models of Modern Human Origins with Archaeology and Anatomy http://www.nature.com/scitable/knowledge/library/testing-models-of-modern-human-origins-with-96639156 Activity Out of Africa vs. Multiregional Hypothesis, with other links http://www.discoveryeducation.com/teachers/free-lesson-plans/investigating-our-past-where-did-humans-come-from.cfm 4 hypotheses explained with changes in culture, technology and climate. Includes flashcards and quizzes http://college.thamesandhudsonusa.com/web/humanpast/summaries/ch04.html 4 models Britannica.com http://www.britannica.com/science/human-evolution/The-emergence-of-Homo-sapiens#ref868013 Chris Stringer 4 models http://link.springer.com/article/10.1023%2FA%3A1011079908461#page-1
9/10/13	The Pacific Migration - the last dispersal	What are your personal experiences of this?	Discussion, letter written to descendent about ancestry, interview family	Students relate their own personal experiences to each other/ small group/ class. Interview family members. Or could use a well-known local example. How did you come to be a New Zealander? What do you now about your own ancestry? How do you know this?

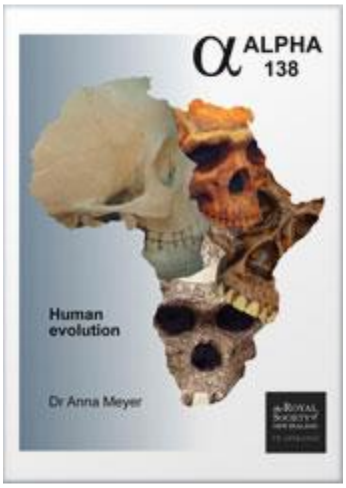
Suggested Year level	What students will learn about (intended LO)	Context question(s)	Possible Learning Experiences	Useful Resource details
		How did we navigate in the Pacific? (particular emphasis on ancient Polynesian techniques) What technology did we need? What did we take with us? What is the Pacific pattern of dispersal? Why is this dispersal so much later? What NZ specific evidence is there for this late dispersal?	Groups to investigate methods of navigation, technology, evidence and then share back to class (jigsaw activity) Make direct contact with NZ researchers and have Skype interview or a real interview. Watch stories of New Zealanders associated with this project. Visit local museum and/or marae to find artefacts	How did we get here – are races real? https://www.youtube.com/watch?v=8C4te2CTleo Easter Island, Tahiti http://www.pbs.org/wgbh/nova/ancient/polynesia-genius-navigators.html Easter Island http://www.pbs.org/wgbh/nova/easter/resources/ Polynesian and European navigation techniques http://www.pbs.org/wgbh/nova/ancient/secrets-of-ancient-navigators.html Thor Heyerdahl and The Kon-Tiki Museum http://www.kon-tiki.no/en/ https://www.youtube.com/watch?v=a_GgV39Iamk (Note- also a film 118min Kon-Tiki) Polynesian dispersal- trade routes, kumara, gourds, chickens, clips to watch about wayfarers http://www.transpacificproject.com/ Kuri DNA evidence http://www.radionz.co.nz/national/programmes/ourchangingworld/audio/201775366/hair-of-the-kuri-or-maori-dog Article about evidence http://www.sea.edu/spice_atlas/rangiroa_atlas/polynesian_migration

Suggested Year level	What students will learn about (intended LO)	Context question(s)	Possible Learning Experiences	Useful Resource details
		(e.g. Wairau Bar artefacts, DNA evidence linked with commensal rats, pigs,(kuri) dogs and chickens)		Sweet potato DNA http://phys.org/news/2013-01-sweet-potato-dna-early-polynesians.html Polynesian Discovery Part 1 (History Channel 8.07) https://www.youtube.com/watch?v=tuJk_a4iWj0 Te Waka: Our Great Journey (NZ Maritime Museum 10.44) https://www.youtube.com/watch?v=7AT4_l4tkB8 Good overview and further links http://www.teara.govt.nz/en/pacific-migrations/page-1 Lens Seminar powerpoint http://lens.auckland.ac.nz/images/e/ef/Polynesian_Settlement.pdf Lisa Matisoo-Smith talking about pacific migration https://www.youtube.com/watch?v=YHgKxHzsEfU *Appendix 4* (lens.auckland.ac.nz/images/3/31/Pacific_Migration_Seminar_Paper.pdf) Wairau Bar general info http://www.teara.govt.nz/en/interactive/31749/wairau-bar-archaeological-site Wairau Bar NZ Listener article http://www.listener.co.nz/current-affairs/historical/where-it-all-began/ Wairau Bar Malborough Museum http://marlboroughmuseum.org.nz/index.mvc?ArticleID=52

Suggested Year level	What students will learn about (intended LO)	Context question(s)	Possible Learning Experiences	Useful Resource details
				Wairau Bar University of Otago Magazine http://www.otago.ac.nz/otagomagazine/issue34/features/otago041598.html Wairau Bar, Shell tool evidence link with Hawaii www.pacificarchaeology.org/index.php/journal/article/download/54/37 Wairau Bar TVNZ Clip (1.48) http://tvnz.co.nz/content/2650840/2483318/video.xhtml

Other relevant supporting material and activities

Royal Society of New Zealand; Alpha Series
Issue 138: Human Evolution



How did our species come to be the way it is today? In this Alpha, we take a look at the scientific topic of human evolution.

First we journey through some of the stages of our past, looking at the human family tree, who some of our common ancestors were and how modern humans came about. Then we focus on some specific questions from our past, including what our relationship is with a well-known prehistoric race of people called Neanderthals, the origins of Polynesians and our relationship with our closest living relatives, chimpanzees.

http://www.royalsociety.org.nz/media/publications-teaching-alpha-138.pdf

http://www.quatrostrategies.com/2016/03/05/latest-info-graphics-on-syria-and-migrant-crisis/

Website with good links and activities includes Hominin dating game etc.
http://www.evolution.wisc.edu/node/135#class

http://www.becominghuman.org/

http://www.neok12.com/Human-Evolution.htm

NCEA Pass Biology website
http://www.passbiology.co.nz/biology-level-3/human-evolution

Overview of what evolution is (change in gene pool over time and how this can happen) Ted Ed Original: Five Fingers of Evolution, Paul Anderson (5.23)
http://ed.ted.com/lessons/five-fingers-of-evolution

http://slideplayer.com/slide/6183216/
http://slideplayer.com/slide/1588363/

https://genographic.nationalgeographic.com/for-educators/

https://www.dnalc.org/view/15892-Human-migrations-map-interactive-2D-animation.html

http://www.hhmi.org/biointeractive/search?sort_by=created&redirect=1&field_biointeractive_topics%5B0%5D=26624

Glossary

Aotearoa	Is the Māori name for the country of New Zealand. The literal translation is "land of the long white cloud".
Chromosomes	Chromosomes are thread-like structures located inside the nucleus of animal and plant cells. Each chromosome is made of proteins and a single molecule of deoxyribonucleic acid (DNA).
Dispersal	The movement of an individual from its birth site to a new location.
Fossil	These are the preserved remains or traces of animals, plants, and other organisms from the remote past in the Earth's crust. Most commonly they are the hard parts of a creature, such as a shell or bones.
Gene	A section of DNA that codes for a protein.
Genome	An organism's complete set of genetic instructions- the sequence of the order of all the bases. This contains all of the information needed to build that organism.
Evolution	Change in the heritable traits of populations over successive generations. May result in speciation.
Haplogroup	Individual branches, or closely related groups of branches on the genetic family tree of all humans. All members of a haplogroup trace their ancestry back to a single individual.
Haplotype	A combination of alleles (DNA sequences) at different places (loci) on the chromosome that are transmitted together.
Hominin	The group consisting of modern humans, extinct human species and all our immediate ancestors (including members of the genera *Homo*, *Australopithecus*, *Paranthropus* and *Ardipithecus*).
Homo sapiens	Modern humans.
Hominid	The group consisting of all modern and extinct Great Apes. That is, modern humans, chimpanzees, gorillas and orang-utans plus all their immediate ancestors.
Mitochondrial DNA (mtDNA)	The DNA located in mitochondria; cellular organelles within eukaryotic cells that convert chemical energy from food into a form that cells can use, adenosine triphosphate (ATP).
Mitochondrial Eve	The hypothetical woman that all mitochondrial DNAs stems from.
Multiregional Theory	Suggests that Homo erectus ventured out of Africa and then evolved into modern man in several different locations throughout the world.
Mutation	A permanent alteration of the nucleotide sequence of the genome of an organism, virus, or extrachromosomal DNA or other genetic elements.
Nuclear DNA	The molecules in the nucleus of eukaryote cells that contain your chromosomes, you get half from each parent.
Out of Africa Theory	Suggests that Homo erectus evolved into Homo sapiens in Africa, and then ventured out of Africa and dispersed to all around the world.

Phylogeny	A tree-like diagram that shows the history of an organisms’ lineages as they change through time.
Species	A group of individuals that are not genetically isolated that interbreed to produce viable offspring
Speciation	The formation of a new, distinct species
Y chromosome	One of the two sex chromosomes in humans (the other is the X chromosome). It contains more than 59 million building blocks of DNA (base pairs) and represents almost 2 percent of the total DNA in cells.

Appendix 1

We're all one family under the skin (Professor Lisa Matisoo-Smith)

NZ Herald, 9th January 2015

With recent events in the United States, Pakistan, Syria and Sydney, it may seem that hatred, religious intolerance and bigotry are taking over. Perhaps it's time to reflect on human history and consider something important given to you by your mother - not her wisdom, which no doubt could also help at times like these, but her mitochondrial DNA.

In 1987, New Zealand-born scientist Allan Wilson and his PhD students, Rebecca Cann and Mark Stoneking, published an extraordinary paper reporting that all modern humans can be traced back to a common female ancestor who lived in Africa some 200,000 years ago. The expansion of people out of Africa began only 60,000 years ago.

This means that most of the cultural, linguistic and physical variation we see in humans today has happened in that 60,000 years: humans occupied and adapted to all possible environments, from the Arctic Circle to the south coast of Australia, the Himalayas to the atolls of the Pacific.

The settlement of Aotearoa, just 750 years ago, was the last step in the great human journey, from Africa to Aotearoa and everywhere in between in 60,000 years.

Allan Wilson recognised the power of the molecule called mitochondrial DNA for tracing human history. Unlike nuclear DNA -- the DNA that makes up your chromosomes, which you inherited from both of your parents and which mixes to form a unique combination that makes you -- your mitochondrial DNA (mtDNA) is passed down to you as an exact copy from your mother.

She inherited it from her mother, who inherited it from her mother and so on.

Every so often, a mutation occurs and one letter in that sequence of 16,500 letters that make up the mitochondrial genome changes and this new sequence is passed down through the generations. By comparing the sequence of mtDNA from people around the world, we can draw our family tree -- a tree that links all modern humans to that ancestral lineage that existed in Africa 200,000 years ago. This common maternal ancestor is often dubbed the mitochondrial Eve.

For the last 18 months I have been meeting New Zealanders across the country, taking cheek swabs that provide a sample of cells from which we can obtain mitochondrial DNA. The goal of the project, called The Longest Journey: From Africa to Aotearoa, is to identify the genetic ancestry of New Zealanders.

We all, either recently or through our ancestors, made the long trip that resulted in our being here in Aotearoa. We can trace those migration pathways through our mtDNA. I've collected random samples from Auckland, Hamilton, Wellington, Christchurch and Dunedin. I have also worked with various ethnic groups, from the Lebanese community in Dunedin to the Dalmatian community in Auckland. It's been a privilege to meet so many Kiwis, to hear their stories and see the amazing diversity present in Aotearoa.

You can't look at someone and guess their mtDNA haplotype (maternal lineage). As it turns out, we have almost every major branch on the mitochondrial tree represented among our population.

While our main interest is understanding deep history, our migration history covering many thousands of years, we're also asking about participants' recent family history. It saddens me how many people don't know their basic family history -- where their mum was born or their mum's mum. Many can phone a family member to find out. Unfortunately, many cannot.

During this holiday period, you might be spending time with family. Talk to them, ask the older generations about their lives, their stories. Record that family information before it is lost. While we can always track our ancient history through our mtDNA, we won't ever get those more recent stories back once they are forgotten. They are precious and part of your personal and our national identity.

With recent events that seem to draw attention to and be motivated by human differences, perhaps it would do us some good to consider our recent shared ancestry and the amazing human history that has seen us spread across the globe.

New Zealand is not the perfect society, but we do have much to be thankful for. We have not been faced with these recent acts of hatred that might drive retaliation. We're in a position right now to decide to act in ways that will continue to make New Zealand a unique, diverse and relatively safe place to live, where everyone is welcome and will not live in fear of persecution because of their colour or place of worship.

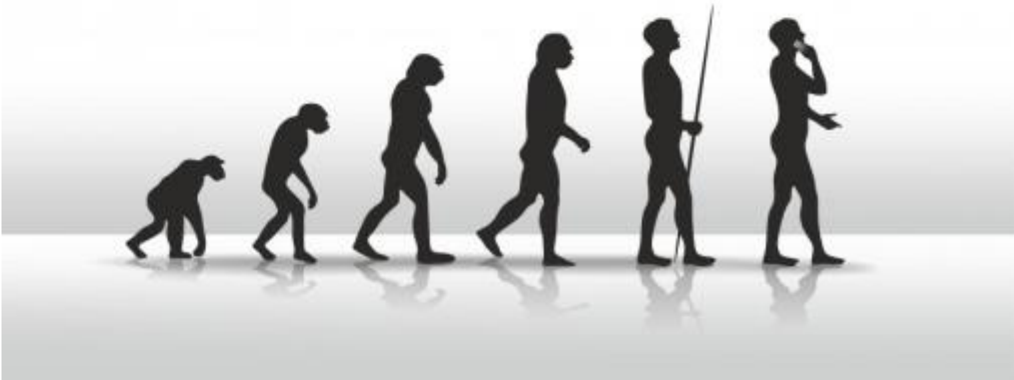
Let us think about our common ancestry while we celebrate our own family histories and traditions.

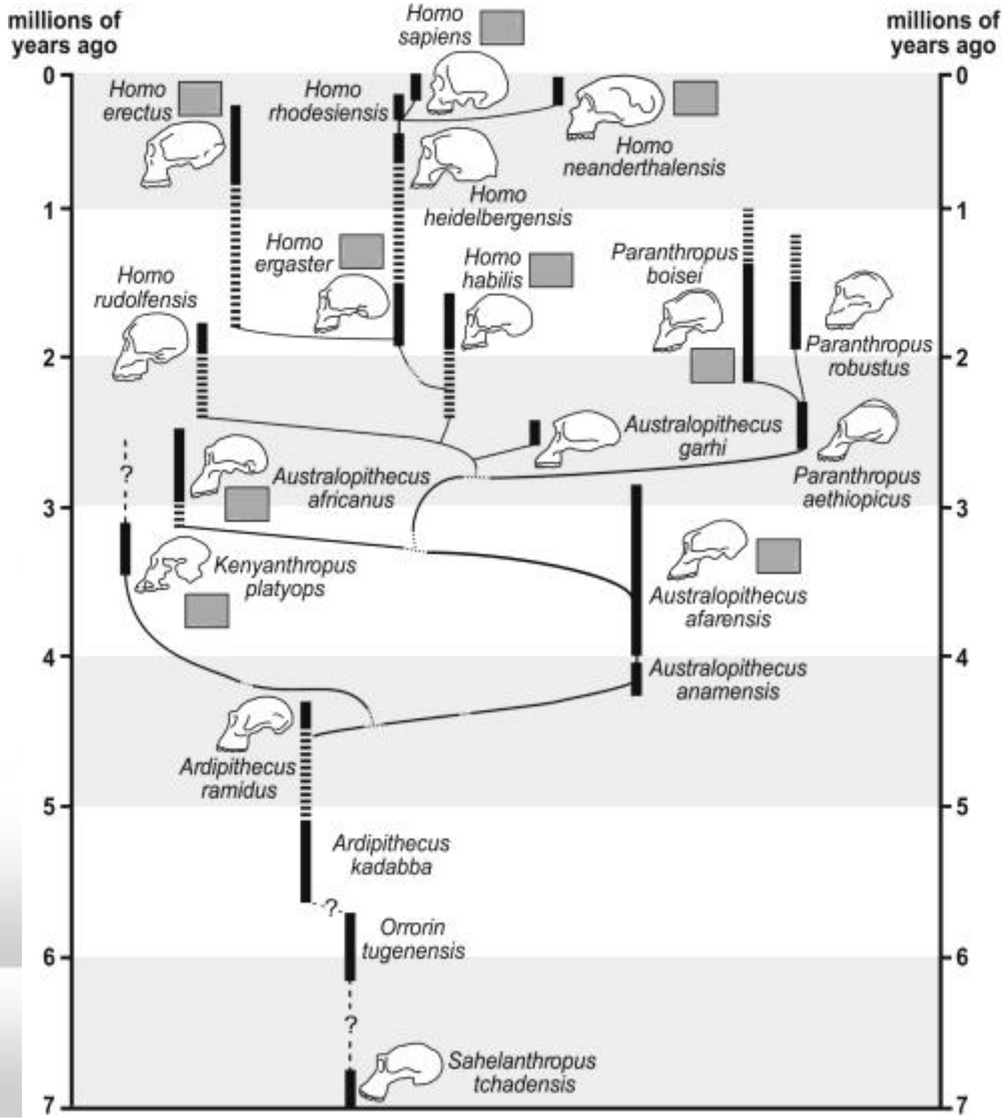
Suggestions for how to use this article:

- Shared whole class reading; pair and share exercise; independent active reading; article summary exercise
- Review language and biological terminology. Clarify technical terms- build glossary; flashcards; wallchart

Appendix 2

Appendix 3

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Homo erectus
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Homo neanderthalensis
Homo heidelbergensis
Homo ergaster
Homo habilis
Homo rudolfensis
Paranthropus boisei
Paranthropus robustus
Australopithecus garhi
Australopithecus africanus
Paranthropus aethiopicus
Kenyanthropus platyops
Australopithecus afarensis
Australopithecus anamensis
Ardipithecus ramidus
Ardipithecus kadabba
Orrorin tugenensis
Sahelanthropus tchadensis
?

Appendix 4

(***lens***.*auckland.ac.nz/images/3/31/****Pacific****_Migration_Seminar_Paper.pdf)*

LENScience CONNECT
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Rethinking Polynesian Origins: Human Settlement of the Pacific

Michal Denny, and Lisa Matisoo-Smith

Our Polynesian ancestors are renowned as some of the world's most successful and innovative navigators. Using their knowledge of tides and stars, Polynesian seafarers explored vast areas of the Pacific. They discovered and settled nearly every inhabitable island in the Pacific Ocean well before European explorers got here in the 16th century.

Māori oral legends tell us that Hawaiki is the legendary homeland from which Māori and Polynesian people explored and colonised the islands of the Pacific and Aotearoa New Zealand. There is also increasing scientific evidence that Polynesians reached South America well before the first Europeans.

The question of humans origins and the mapping of human movement around the world is one that has long interested science. Scientists use both biological, linguistic and cultural evidence to investigate the origins of human populations.

Allan Wilson Centre anthropologists Lisa Matisoo-Smith, is part of a team of researchers investigating questions about the origins of Polynesians such as:

- Where did the ancestors of Polynesians come from?
- What route did the settlers take through the Pacific?

Answering questions like this is the role of a field of science called biological anthropology.

Anthropology traces the evolution of culture from its primate origins, through over five million years of prehistory, to historical and contemporary societies.

Lisa Matisoo-Smith is Professor of Biological Anthropology at the University of Otago and Principal Investigator in the Allan Wilson Centre. Her research focuses on identifying the origins of Pacific peoples and the plants and animals that travelled with them, in order to better understand the settlement, history and prehistory of the Pacific and New Zealand. Her research utilises both ancient and modern DNA methods to answer a range of anthropological questions regarding population histories, dispersals and interactions.

ALLAN WILSON CENTRE

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND

The research process

All research starts by finding out what is already known about the topic. In this case human dispersal out of Africa and human settlement of the Pacific. This process is called a literature search and involves identifying all relevant published research in the field. This is used to decide on the research questions that will underpin new research.

What is already known about human migration?

- There was a migration of anatomically modern humans out of Africa around 150,000 – 100,000 BP (Years Before Present), moving east towards Asia and north into Europe.
- Part of this migration reached South-East Asia by 60,000 BP.
- Populations of these stone-age hunter gatherers then expanded from Southeast Asia into the Pacific through New Guinea to Australia and the Bismarck Archipelago by about 45,000 BP
- Once in Southeast Asia and Australia the movement of humans into new areas stopped for nearly 30,000 years.
- A later wave of expansion out into the rest of the Pacific took place began around 3,500 BP.
- In this migration the people went east to Samoa and Tonga and from there north to Hawaii, further east to Easter Island and south to New Zealand.
- This was the last major human migration event.

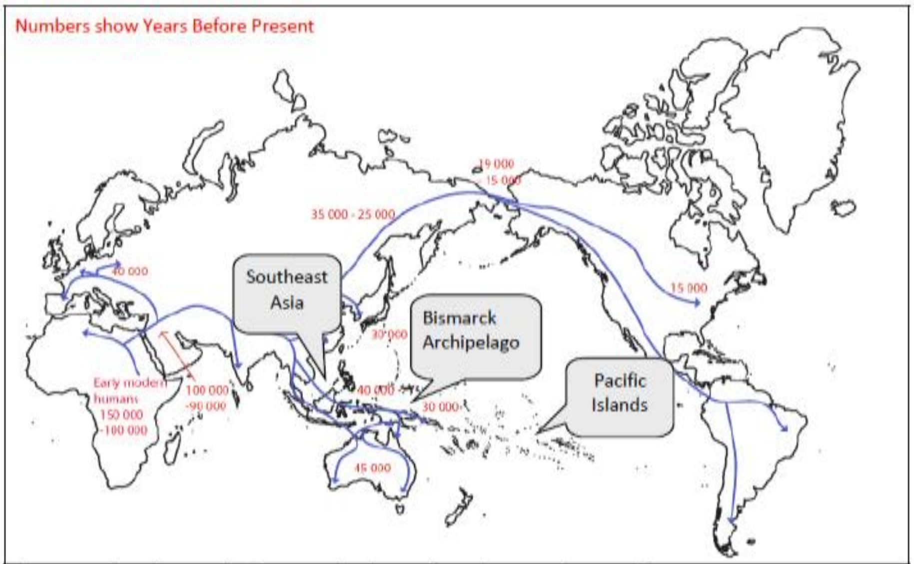


Figure 1. The dispersal of anatomically modern humans from Africa

Research Questions

These are the types of questions that came out of the background research:

1. Who are the ancestors of modern Pacific peoples?
2. Where were the geographic origins of these ancestors ?
3. What route or routes did they take in their migration through the Pacific?

Molecular biotechnological techniques are now an important tool in collecting data to answer these questions, particularly for looking at mitochondrial DNA (mtDNA) and the Y chromosome. mtDNA and the Y chromosome are used in this type of research because they are inherited from only one parent and they do not recombine (or mix) with DNA from the other parent. Scientists are interested in variation or differences in the mtDNA or Y chromosome between different populations in different areas as these can indicate likely movement of the founding population.

The origins of Polynesian Peoples

Polynesia is defined as the islands found roughly in a triangle formed by Hawaii, Aotearoa-New Zealand and Easter Island (Rapa Nui) (See Figure 2).

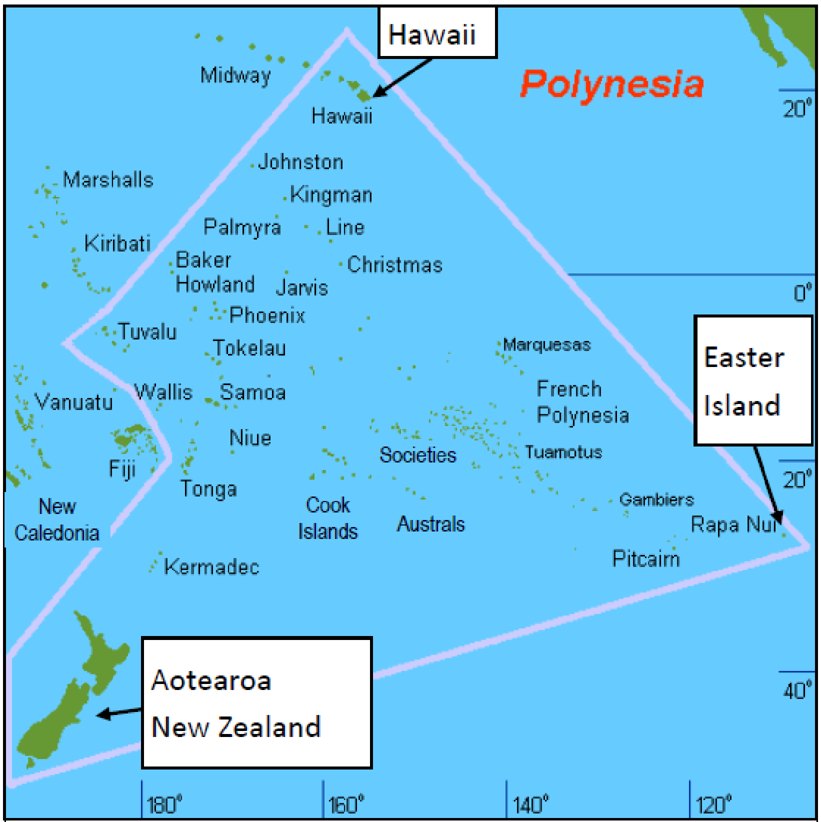


Figure 2: The Islands of Polynesia

Figure 3: Near and Remote Oceania

When looking at human settlement of the Pacific, anthropologists divide the Pacific into two regions (See Figure 3):

- Near Oceania, which was settled by humans by 30,000 BP.
- Remote Oceania, which was not settled until around 3000 BP. Notice that Polynesia is in Remote Oceania

Figure 4: Pieces of Lapita pottery

Source: Department of Anthropology, University of Auckland.

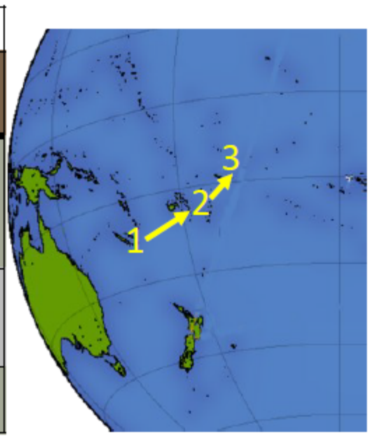
The first human settlers of Remote Oceania are associated with the Lapita culture, which first appeared in the Bismarck Archipelago in Near Oceania around 3500 BP. (An archipelago is a chain or cluster of islands formed from volcanic activity).

The Lapita culture is named after the distinctive patterned pottery seen in Figure 4, which was first found at a site called Lapita in New Caledonia. Anthropologists are very interested in who the Lapita people were and what role they played in the settlement of the Pacific.

Remnants of Lapita pottery are now found throughout many areas of Remote Oceania, which suggests that the Lapita people were the first to settle this area. Table 1 shows how the age of the pottery remains found in each area supports the idea that this settlement spread from west to east from Melanesia into Polynesia.

Table 1: Location and dates of Lapita Archaeological sites

Location of Lapita Archaeological sites	Date (years before present)
1. Reef and Santa Cruz Islands Vanuatu New Caledonia	~3000 BP
2. Fiji Tonga	~2900 BP
3. Samoa	~2700 BP



Evidence such as this suggests that the Lapita people are the ancestors of modern Pacific peoples, but questions remain about whether there could also have been contributions from other populations from Asia and Micronesia at later times.

Models for human settlement of the Pacific

Prior to the development of molecular biotechnological techniques, scientific understanding of human settlement in the Pacific was developed by collecting evidence from archaeological studies (remains of Lapita pottery and Polynesian pottery), language, physical and cultural comparisons, and studies of blood groups and the limited genetic data available at the time. By the early 1990's it was commonly accepted by anthropologists that the only ancestors of the Polynesians were the Lapita peoples. Evidence for this hypothesis (or model) came from:

- Archaeological remains like the pottery in Table 1, suggested that Lapita were the first humans in the region,
- relatively limited variation in culture and languages between Polynesians, and
- a unique Polynesian phenotype i.e. little variation in physical appearance between the different populations, particularly in comparison to the biological variation found in Melanesia.

This model is often called the **Lapita-only** model of human settlement of the Pacific.

Like all scientific models and hypotheses, scientists collect further evidence to either strengthen or modify the model. One of the key researchers in this area has been Lisa Matisoo-Smith from the Allan Wilson Centre.

Using molecular biotechnologies, Lisa and her fellow researchers have found evidence which suggests that the hypothesis that the Lapita were the only ancestors of Polynesians may not be the completely explain the situation.

Research carried out by Lisa and her team has focussed on determining the genetic origins of animals and plants that are known to be associated with human settlements in the Pacific. These are known as commensal plants and animals because they have a close relationship with humans – as food items, companions, or because they are important for other cultural reasons. Examples of these animals include rats, pigs, dogs, and chickens. Importantly these animals cannot get from one island to another unless they are taken there by humans, therefore scientists can track the movements of the humans by tracking the movements of these commensal animals that travelled with the humans.

The first commensal animal that Lisa's team studied was the Pacific rat or Kiore (*Rattus exulans).* Kiore is a good animal for this because:

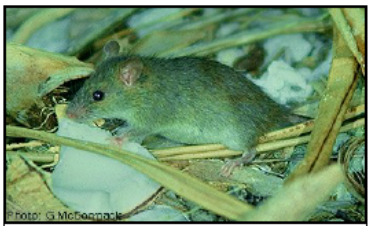


Figure 6: Pacific Rat.
Picture from Cook Islands Biodiversity Database: http://cookislands.bishopmuseum.org/species.asp?id=8745

- it was often intentionally transported in colonising canoes as a source of food
- it cannot swim so can only get to new islands by being carried in canoes with people,
- it reproduces rapidly and thus accumulates mutations faster than humans,
- it is a different species from the European rats that were introduced later and therefore can not interbreed with them. This means any current populations of Pacific rats are direct descendants of the original populations and
- remains of Pacific rats appear in the earliest layers of archaeological sites associated with Lapita people and are found in all sites associated with Lapita and later Polynesian settlement.

Molecular biotechnologies offer advances in understanding

The first study looked at the variation in the mitochondrial DNA (mtDNA) of living populations of Pacific rats from islands around the Pacific. mtDNA is inherited only from the mother, therefore there is no mixing with the father's DNA or recombination during meiosis. This means that differences in the mtDNA due to mutation can be traced back through the generations. Scientists use the variation in the mtDNA to work out the relationships between different populations.

The results of this study suggested that it is highly likely that there were multiple introductions of the Pacific rat to the Pacific Islands. This raised the question, "did these introductions all occur at the same time or at different times?" If they were at different times then this suggests that another group of people migrated into the Pacific sometime after the Lapita people.

This question cannot be answered by studying modern mtDNA, as variation in modern mtDNA only shows different origins,—it doesn't show the timing. Ancient DNA, however, could be used to answer this question. Ancient DNA is any DNA extracted from tissues such as bone that are not fresh or preserved for DNA extraction later. When an organism dies, the DNA molecules immediately start to break down, which makes it difficult to extract good quality DNA for analysis. The hot and wet environment found in most of the Pacific makes it just about the worst area for DNA preservation. Despite this Lisa and other Allan Wilson Centre researchers have been able to obtain DNA from Pacific samples as old as 3000—4000 years[2].

If the age of the remains is known then the likely date of the introduction of new genetic material can be estimated. The team next investigated ancient DNA from the remains of Kiore found in different archaeological sites around the Pacific looking for patterns in the haplotypes in mtDNA. A haplotype is a combination of alleles that are located closely together.

Lisa found three distinct groups of haplotypes, - shown as Groups I, II and III in Figure 7. Three clearly different haplotypes (or genetic groups) is an indication that these populations of rats are likely to have quite different ancestral origins.

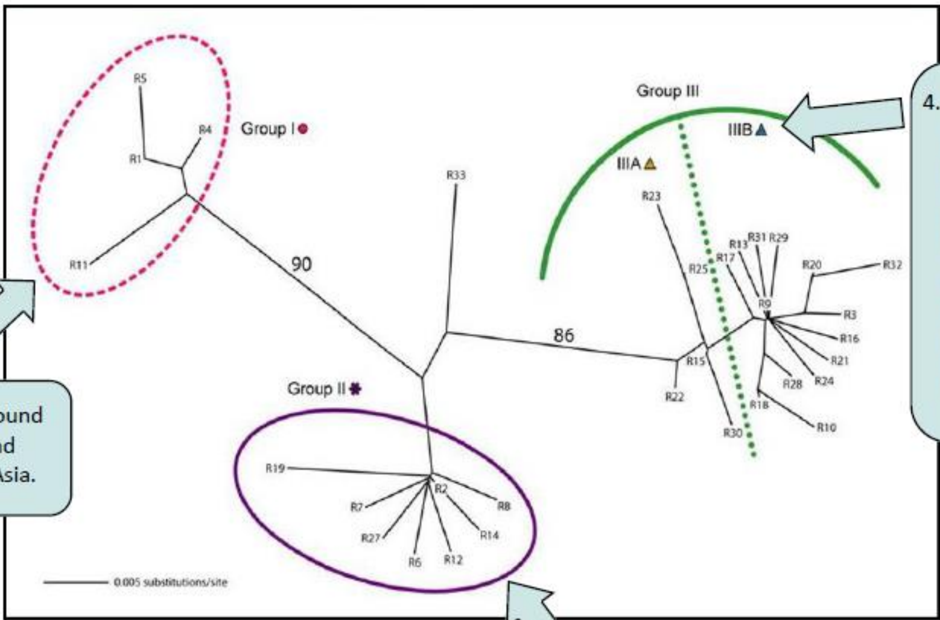


Figure 7: Pacific rat mtDNA haplotypes
From: Matisoo-Smith, E., & Robins, J. H. (2004)

1. Group I is found only in Island Southeast Asia.

2. Group II includes samples found in Island Southeast Asia and Near Oceania. This fits with the model of the Lapita people originating in Southeast Asia and then spreading into Near Oceania.

3. Group III consists of all the samples from Remote Oceania. Haplotype IIIB is found throughout Polynesia.

4. Haplotype IIIB is quite different from the Group I and II haplotypes found in the Bismarck Archipelago and other islands of Near Oceania where the Lapita first originated.

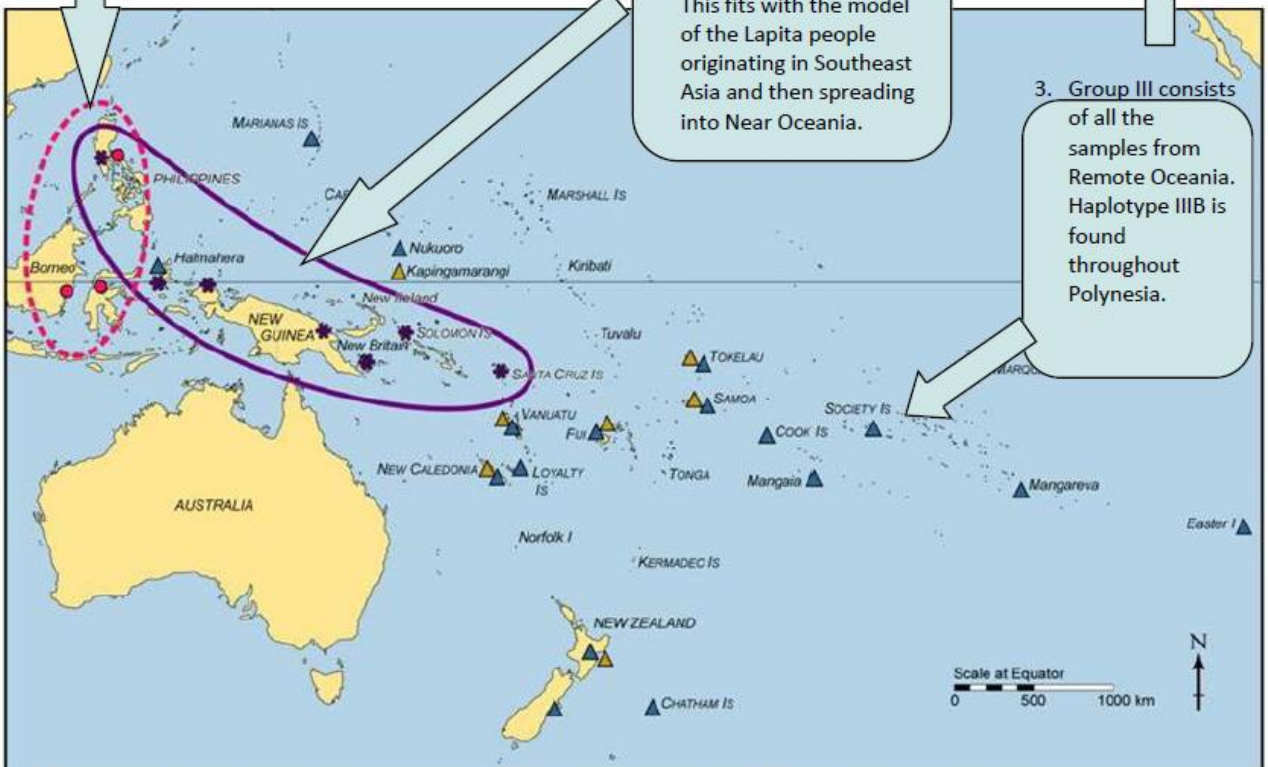


Figure 8: Distribution of the three groups of Pacific Rat haplotypes in Near and Remote Oceania.
From: Matisoo-Smith, E., & Robins, J. H. (2004)

Group III does not fit the expected pattern. It shows no genetic link with the haplotypes found in Near Oceania. This suggests that this haplotype may be the result of a later introduction of the Pacific Rat into Polynesia sometime after the Lapita introduction.

To test this hypothesis Lisa and her team carried out similar studies of variation in both modern and ancient mtDNA in pigs and chickens. In both of these animals the results showed there are introductions that are consistent in geographic distribution and time of appearance in the archaeological record with a Lapita introduction. But other mtDNA studies on dogs of the Pacific, plus the rat and chicken data all indicate a second introduction. This suggests a second population migration out of Asia sometime after 2000 BP.

Conclusion

These results have led Lisa and her colleagues to suggest a new model for Polynesian origins[1]. It is based on an existing framework for Lapita origins suggested by Roger Green in 1991. Here are the key ideas:

1. The Lapita colonists in West Polynesia and the rest of Remote Oceania look very much like the current indigenous populations of Vanuatu, New Caledonia and western Fiji
2. Around 1500 BP a new population arrived in Western Polynesia with new and more typically Asian derived physical characteristics, and mtDNA lineages.
3. These new people also introduced new mtDNA lineages of commensal rats, dogs and chickens.
4. There was intense and complex interactions with the existing Lapita-descended populations as they spread over West Polynesia.
5. This resulted in the formation of the Ancestral Polynesian culture, who then dispersed east, and north into the rest of Polynesia.

This possible scenario is shown in Figure 9. The grey arrows show the initial Lapita expansion through Near Oceania and into Remote Oceania. The dotted arrows show the proposed arrival of new population (or populations) from Asia into West Polynesia. The black arrows show the settlement of East Polynesia and a back migration into Melanesia.

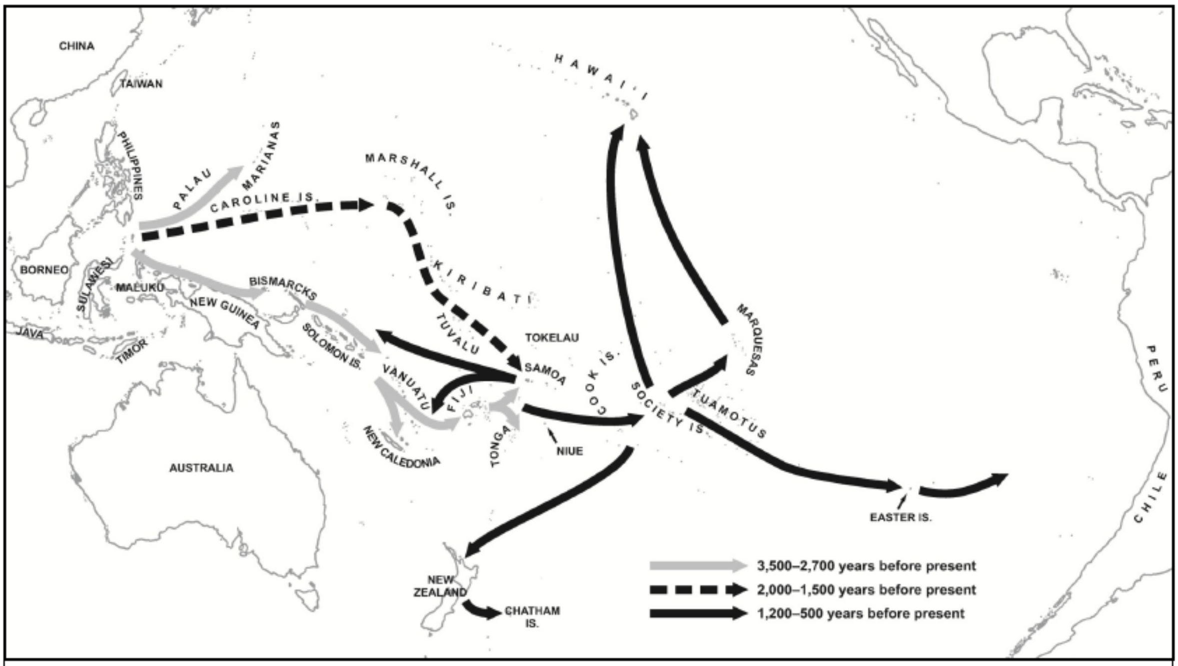


Figure 9: A new model for the origins of Polynesians
From: Addison, D. J., & Matisoo-Smith, E. (2010) *Used with permission from Archaeology in Oceania*

Implications of Founder Effects on Genetic Diversity

> Founder Effect - the loss of genetic variation that occurs when a new population is established by a very small number of individuals from a larger population.

Polynesian populations are relatively genetically homogenous i.e. they have little genetic variation. This is due in part to the fact the original settlers moved into unoccupied areas of the Pacific creating little opportunity for interbreeding with other populations. However, the major contributor to low genetic variability is most likely a founder effect. As canoes were the only method of transport around the Pacific, new islands would probably be settled by only a small number of people. It is also quite likely that these people were closely related and genetically not representative of the larger population that they came from. Numerous studies of mtDNA have shown that mtDNA variation decreases from east to west across the Pacific, which supports the idea of founding populations.

The settlement of Aotearoa New Zealand is a classic example of a founder effect. Māori oral traditions tell us that the ancestors of the Māori came to Aotearoa New Zealand in a series of canoe voyages, with up to 40 different canoes arriving over a long period of time[(4)]. It is thought that up to 500 settlers may have arrived in Aotearoa New Zealand over several generations. Even though this sounds a large number; in population terms it is quite small and therefore likely to result in a founder effect.

A genetic study in the late 1990's of 54 unrelated Māori identified only four different mtDNA lineages. This was the lowest of any human group studied. Out of those 54 people, 47 of them had the same mtDNA lineage. In addition while this lineage was also seen in other Pacific populations, it occurred at the highest frequency in Māori as shown in Figure 10[(5)].This shows that there is only limited mtDNA variation in Māori which is consistent with the founder effect.

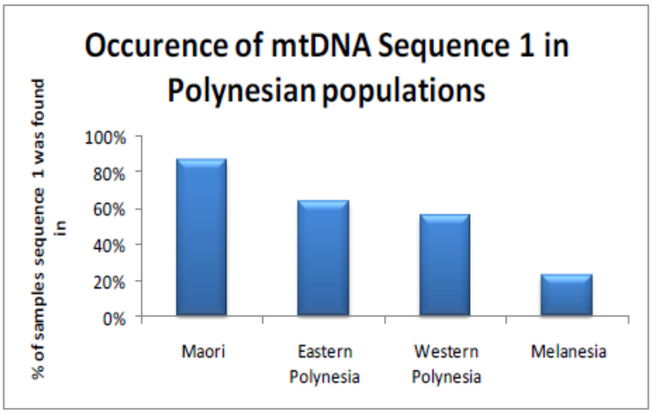


Figure 10.

Occurrence of mtDNA sequence 1 in Polynesian populations

Data from: Murray-McIntosh, R. P *et al* (1989)

The data from this study was then used to estimate the likely number of females in the founding population of New Zealand Māori . Computer simulations were run using the data and came up with a figure of between 50 and 100 women, which is consistent with Māori oral history.

The Genographic Project

The Genographic Project is a five-year research project involving a team of scientists from around the world. It aims to find out new information about the migratory history of the human species and in doing so answer questions like:

- Where do you **really** come from?
- How did you get to where you live today?

The researchers are using cutting-edge genetic and computational technologies to analyse historical patterns in DNA from participants around the world to better understand our human genetic roots. Lisa joined the Genographic project as a Principal Investigator in 2008 to further the project's work with Pacific Island communities.

References

1. Addison, D. J., & Matisoo-Smith, E. (2010). Rethinking Polynesians origins: a West-Polynesia Triple-I Model. *Archaeology in Oceania, 45*(1), 1-12.
2. Allan Wilson Centre. (2010, April). Ancient DNA. *Pheno*. Available at http://www.allanwilsoncentre.ac.nz/documents/newsletters/Pheno4.pdf
3. Matisoo-Smith, E., & Robins, J. H. (2004). Origins and dispersals of Pacific peoples: Evidence from mtDNA phylogenies of the Pacific rat. *Proceedings of the National Academy of Sciences of the United States of America, 101*(24), 9167-9172. Available at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC428491/
4. Rāwiri Taonui. 'Canoe traditions', Te Ara - the Encyclopedia of New Zealand, updated 16-Mar-09 http://www.teara.govt.nz/en/canoe-traditions
5. Murray-McIntosh, R. P., Scrimshaw, B. J., Hatfield, P. J., & Penny, D. (1998). Testing migration patterns and estimating founding population size in Polynesia by using human mtDNA sequences. *Proceedings of the National Academy of Sciences of the United States of America, 95*(15), 9047-9052. Available at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC21200/pdf/pq009047.pdf

For further information contact Michal Denny m.denny@auckland.ac.nz; Lisa Matisoo-Smith lisa.matisoo-smith@anatomy.otago.ac.nz

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Appendix 5

The complete genome sequence of a Neanderthal from the Altai Mountains

Kay Prüfer,[1] Fernando Racimo,[2] Nick Patterson,[3] Flora Jay,[2] Sriram Sankararaman,[3,4] Susanna Sawyer,[1] Anja Heinze,[1] Gabriel Renaud,[1] Peter H. Sudmant,[5] Cesare de Filippo,[1] Heng Li,[3] Swapan Mallick,[3,4] Michael Dannemann,[1] Qiaomei Fu,[1,6] Martin Kircher,[1,5] Martin Kuhlwilm,[1] Michael Lachmann,[1] Matthias Meyer,[1] Matthias Ongyerth,[1] Michael Siebauer,[1] Christoph Theunert,[1] Arti Tandon,[3,4] Priya Moorjani,[4] Joseph Pickrell,[4] James C. Mullikin[7] *et al.*

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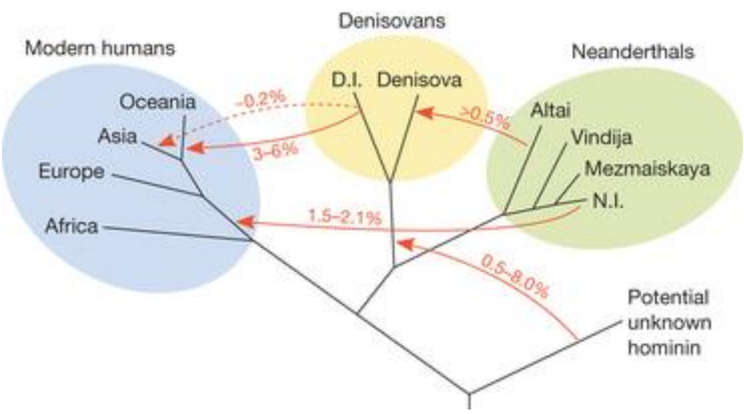


http://www.nature.com/nature/journal/v505/n7481/full/nature12886.html

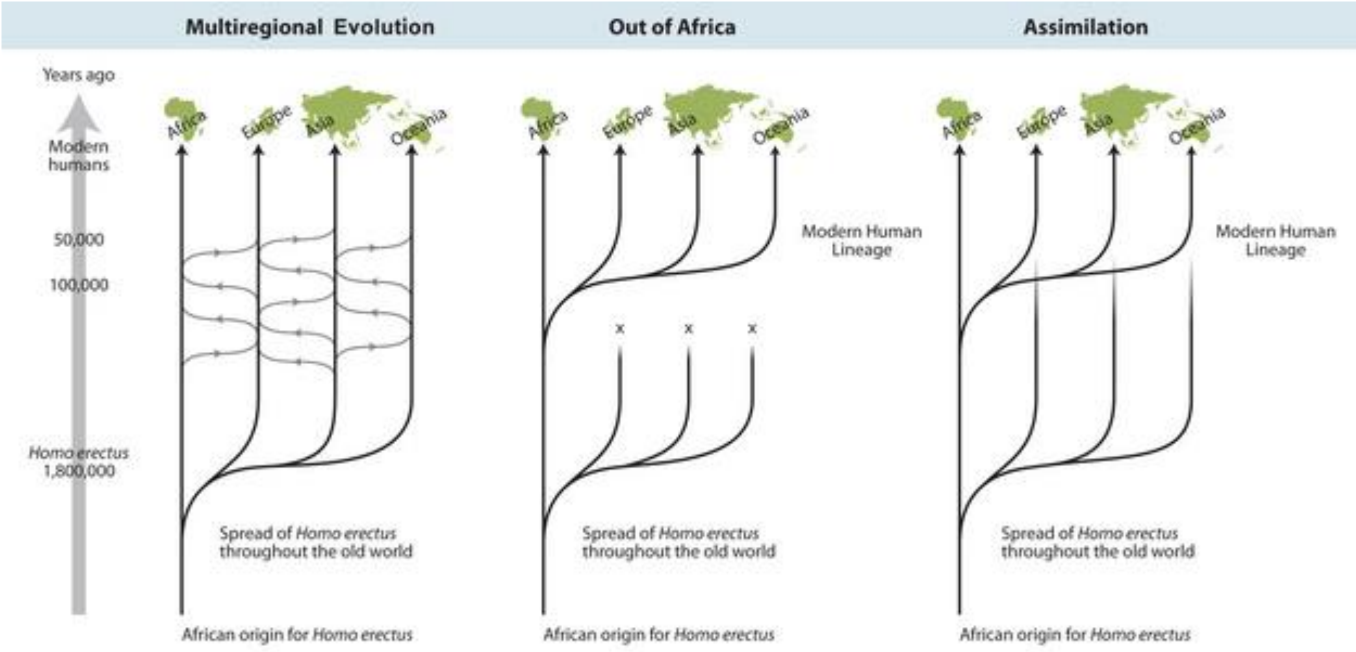
Appendix 6

Name: ______________________ Fossil finds location: Height: Brain size: Skeleton: Culture: Time period: Interactions with modern humans: Interesting features	Name: ______________________ Fossil finds location: Height: Brain size: Skeleton: Culture: Time period: Interactions with modern humans: Interesting features

Appendix 7

Dispersal across Fresh Polynesia overlaid across Europe (http://www.air-tahiti-polynesia.com/). Took about 200 years to spread whereas it took thousands of years to go over Europe.

Appendix 8 – models of human dispersal



Testing Models of Modern Human Origins with Archaeology and Anatomy
http://www.nature.com/scitable/knowledge/library/testing-models-of-modern-human-origins-with-96639156

Appendix 9 – National Genographic Profile Female

Appendix 10 – Male Genographic profile Richard emailed 26.4