Evo Edu Outreach (2008) 1:281–286
DOI 10.1007/s12052-008-0058-3

VIEWS FROM UNDERSTANDING EVOLUTION

A Look at Linguistic Evolution

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Published online: 20 June 2008

Keywords Linguistic evolution · Natural selection · Genetic drift · Homology · Phylogenies · Teaching

Anyone who has ever tackled a Shakespeare play knows that English has changed substantially in the 400 years since Elizabeth I ruled England. In fact, Elizabethan English can seem like a completely different language from the one we speak today. Just try describing your mood with the Shakespearean terms *allicholly* and *tetchy*—you are more likely to get confused looks than sympathy for being unhappy and irritable. Four hundred years from now, English speakers will likely feel the same way about the language we speak today. Unless you are keeping up with the latest additions to the Oxford English Dictionary, you might already be behind the times: Do you know if you would be eligible to participate in a *girlcott*? Or whether you would want a job as a *helmer*? Or when it would be appropriate to wear a *jandal*?

It is clear that languages change. In an article in this issue, Venditti and Pagel (2008) take that notion one step further. They explain that languages do not simply change over time, but instead evolve in a process that parallels biological evolution. Venditti and Pagel take methods designed for analyzing the rates of evolution of new species and use them to learn more about the rates at which new languages form. Here, we will dig into the idea of linguistic evolution and see exactly how it is similar to and different from biological evolution.

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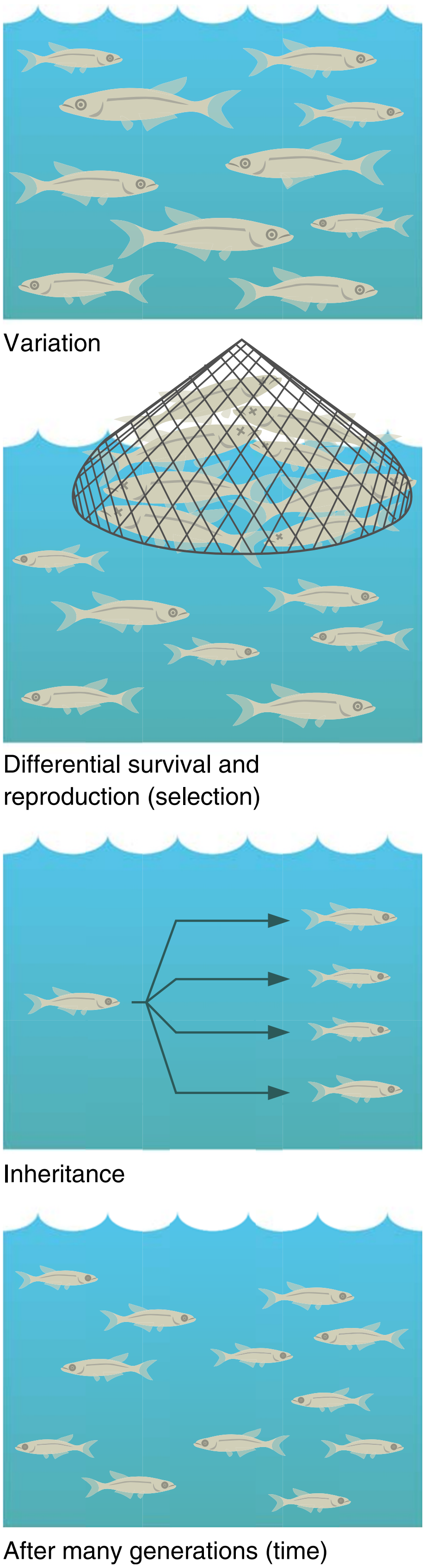
The essence of biological evolution at the level of the individual organism is variation, inheritance, differential survival and reproduction, and time. Individuals within a population vary in the traits they have. Many of those traits are genetically encoded—and so are heritable. If individuals with particular traits happen to leave behind more offspring, those traits will be over-represented in the next generation. Over many generations, this process can lead to major evolutionary change. So, for example, if fish within a population vary in body size, if body size is influenced by heritable genes, and if larger fish are less likely to reproduce (perhaps because they tend to get caught in fishing nets), the fish population will evolve smaller body sizes over time (Fig. 1). The same basic process is at work whether we are talking about the evolution of fish body size, the evolution of bacterial antibiotic resistance, or the evolution of human lactose tolerance.

These ingredients—which you can remember with the handy mnemonic VIST (variation, inheritance, selection, and time; Understanding Evolution. Focus on the Fundamentals 2006)—inevitably lead to evolution via natural selection. The same concepts apply to languages, but in a slightly modified form:

- **Variation**: In biological evolution, variation usually takes the form of physiological, anatomical, or behavioral traits and comes about as the result of random mutation. For example, a mutation could cause an individual fish to have a slightly smaller body size than other individuals in the population. In linguistic evolution, variation takes the form of new words, pronunciations, and grammatical structures and may come about as the result of human invention. For example, people arriving on an uninhabited island may find that they need a word for an unfamiliar plant species and simply make one up.



◀ **Fig. 1** An example of natural selection operating on a fish population. The preferential netting of large fish causes the fish population to evolve smaller body sizes. Illustration adapted with permission from the Understanding Evolution website

- **Inheritance**: Biological traits are encoded in DNA. They are usually passed on from parent to offspring—though some organisms (e.g., bacteria) can also directly pass bits of DNA, and the traits they encode, back and forth to one another. Linguistic variation, on the other hand, is "inherited" through learning. Children are likely to learn linguistic traits from their parents and others around them. Just as red-furred squirrels are likely to have red-furred offspring, parents who speak with a southern drawl are likely to have children who speak with a southern drawl. Linguistic "inheritance," though, is much fuzzier and more flexible than biological inheritance. Like bacteria slipping stretches of DNA to one another, human learning allows people to share new words, pronunciations, and grammatical structures with each other directly—even if the two people are not closely related and originally spoke different languages.
- **Selection**: As selection acts on organisms, individuals with particular traits are more likely to successfully reproduce than others. Those advantageous traits might be anything from having coloration that blends into the environment better to producing a particularly far-reaching mating call. Correspondingly, individuals with certain disadvantageous traits (e.g., not being able to use a key amino acid) do not leave behind as many offspring. In linguistic evolution, selection takes a slightly different form. Some words or structures may be more memorable or useful and, hence, may be more likely to "reproduce"—i.e., be passed on to others. For example, today the words *blog* and *bandwidth* are more likely to be shared than a word like *calash* (the folding hood of a horse-drawn buggy).
- **Time**. Over time, both biological and linguistic evolution can produce major changes—whether that means the radiation of new clades of terrestrial vertebrates after the dinosaur extinction or the development of new dialects as people discovered and settled on the Pacific Islands.

Because languages experience variation, inheritance, and selection over long periods of time, they *can* evolve in a process that parallels biological natural selection. However, the differences described above change the process in a few key ways:

- In biological evolution, new variation is introduced via a process of random mutation—that is, mutations occur without regard to what would be useful to the organism. So, for example, a population of plants living in an area affected by climate change cannot produce new drought-tolerant mutants just because they would be helpful. In linguistic evolution, on the other hand, a person can invent a new word that would be particularly handy in the current situation, introduce it to the language, and begin to pass that word on to other people. This is not to suggest that *all* linguistic innovation is deliberate. New words and linguistic structures can arise in many ways. Nonetheless, the possibility of such intentionality can shift the direction of linguistic evolution in a manner not possible in biological evolution.

- Horizontal transfer—the process of passing genes (or in this case, linguistic elements) to individuals other than offspring—may be more common in linguistic evolution than it is in biological evolution. For most organisms with which we are familiar, the units of inheritance (genes) are passed mainly from parent to offspring. But in languages, the units of inheritance (e.g., words) can be easily shared with almost anyone. For example, English now includes many words picked up from other languages—like the word *shampoo* which was probably passed to English from Hindi in the 1700s or earlier (The Oxford English Dictionary 1989). Given the ease with which words can be shared across languages, horizontal transfer at this level is surprisingly infrequent; languages maintain their integrity despite the possibility of a foreign onslaught (Pagel and Mace 2004). Nevertheless, by regularly introducing new variation to languages, the process of horizontal transfer allows linguistic evolutionary change to occur more quickly.
- In biological evolution, advantageous traits provide a reproductive boost to individual organisms. So fish with small body sizes leave behind more offspring in heavily netted areas, and the small body size trait spreads for this reason. In linguistic evolution, however, words may, but need not, provide any particular survival or reproductive advantage to their users in order to proliferate. Words like *blog* and *bandwidth* may be spreading like wildfire but probably are not doing much for the reproductive capabilities of those of us who use them. This disconnect between linguistic variation and reproductive advantage helps decouple linguistic and biological evolution.

Despite these differences, biological evolution and language evolution are similar enough that many of the same concepts and tools can be applied to both situations. We have seen that languages can evolve via natural selection; they can also evolve via drift as biological systems do. Evolution via genetic drift works much like evolution via natural selection, but with one key difference: differential survival and reproduction (the selection step described above) are caused, not by advantageous or disadvantageous traits, but by random chance. Some individuals *happen* to leave more offspring in the next generation than do others—but not because of a special ability to resist predation, get nourishment, or attract mates—because they simply got lucky. Though drift operates via random chance, it can still end up causing major evolutionary change. Some traits can drift out of a population entirely, others can spread and become “fixed” (possessed by all members of the population).

The same process operates on languages. Imagine a group of people shipwrecked on an island. Some of them tend to use the word *zero* and others tend to use the word *naught* to refer to the same thing. After many, many generations on the island, *zero* falls into disuse and out of the language entirely—not because it is hard to remember or ineffective—but because people just happened to use *naught* more frequently. In this case, the word *zero* goes extinct in the island dialect through the process of linguistic drift.

Even technical, genetic concepts can be fruitfully applied to linguistic evolution. For example, biologists have found that some sorts of genes do not evolve much—even through many speciation events and over many millions of years. Housekeeping genes are involved in the basic jobs that keep cells functioning and alive. Because they are so important and are turned on all the time, such genes evolve very slowly and are similar even among distantly related species. Linguistics has its own equivalents to housekeeping genes. “Workhorse” words that get used all the time—like numerals and the pronouns *I*, *you*, *he*, and *she*—evolve very slowly (Pagel et al. 2007). Just consider the words *seven* (in English) and *sieben* (in German). They are remarkably similar even though much of the rest of our vocabularies have diverged—as will be readily apparent to any English speaker who tries to navigate via the traffic signs in Berlin.

The words *seven* and *sieben* are an example of what linguists would call cognates and what evolutionary biologists would call homologies. These are words whose similarities can be chalked up to common ancestry. The bones in your arm and the bones in a whale’s fin are homologous (Fig. 2). They share the same basic layout because humans and whales share a common ancestor who passed that bone arrangement on to each of us. In the same way, the words *seven* and *sieben* are similar because they both descended from one word in a common ancestral language, West Germanic, which had begun to evolve by about 300 BC (Robinson 1994). West Germanic, in turn, evolved from an even older language—Proto-Germanic. Linguists have reconstructed the Proto-Germanic ancestor of *seven* and *sieben* to be something like *sebun* (Ringe

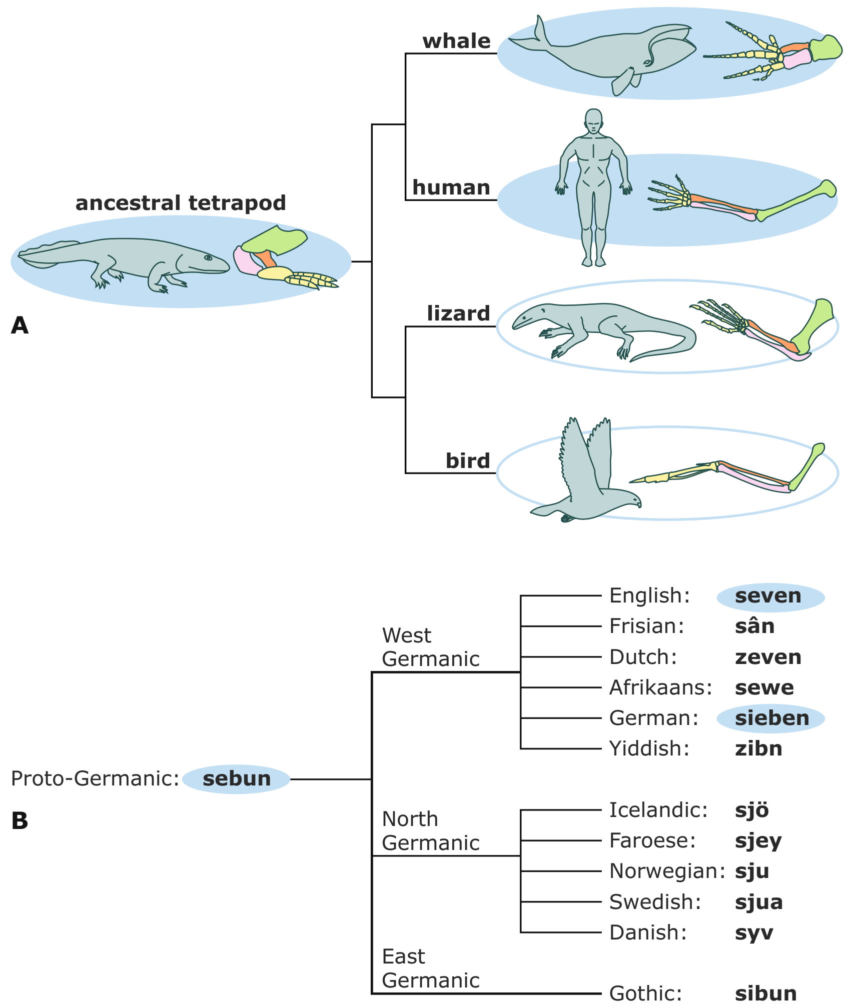


Fig. 2 Phylogenies illustrating the concept of homology. **a** The bones in a whale's fin and a human's hand are homologous. Both sets of bones are descended from the same structure in a common ancestor. Illustration adapted with permission from the Understanding Evolution website. **b** The words *seven* in English and *sieben* in German are homologous. They are both descended from the same word in their common ancestral language. Language phylogeny adapted from Campbell (2004)

2006)—much as evolutionary biologists have pieced together different lines of evidence to figure out what the ancestor of humans and whales must have looked like.

In biological evolution, homologous structures can be used to reconstruct phylogenies—the branching trees that depict the evolutionary relationships among organisms. As you might guess, cognates (linguistic homologies) are used to reconstruct the relationships among languages. The study of punctuated language evolution described by Venditti and Pagel in this issue is based on this principle (Atkinson et al. 2008). The researchers collected hundreds of words from different language families—for example, the word for *two* from 95 different Bantu languages—determined which were homologous to one another, and used this information to construct a family tree of the language group.

Venditti and Pagel used concepts and tools borrowed directly from evolutionary biology to illuminate our linguistic history—revealing that the early development of a new dialect can be a turbulent time, with many words changing all at once. Though they focused on language change, the same evolutionary concepts and tools can be applied to any system that involves variation, some form of inheritance, differential survival and reproduction, and time for the cycle to repeat itself over and over. This means that much cultural information—cuisines, folk art styles, religious traditions—can also be examined in an evolutionary light.

Consider the Lemba, a tribe from southern Africa. Unlike their neighboring tribes, the Lemba's traditions include male circumcision and dietary restrictions like those of the Jewish faith—a group whose ethnic roots are planted several thousand miles away. Taking an evolutionary perspective might lead us to wonder if the similarities between Lemba and Jewish traditions are homologous or analogous—that is, did the traditions descend, with slight modification, from the same practice in some historical group of people, or did they arise separately? Several lines of evidence suggest that these traditions are homologous: Other oral traditions of the Lemba (like the idea that they migrated to South Africa from the Middle East) are consistent with Jewish ancestry—and, perhaps most convincingly, geneticists have found that many Lemba men carry genetic sequences on their Y chromosomes that are typical of Jewish populations (Spurdle and Jenkins 1996). Some Lemba *do* seem to have ethnic roots in Jewish populations and probably brought their slowly evolving cultural traditions with them when they left the Middle East.

The Jewish ancestry of Lemba cultural traditions illustrates one final point about biological, cultural, and linguistic evolution. Since they are inherited in different ways, the paths traced by these different forms of evolution—even within the same group of people—need not be identical. Evolutionary analyses of Lemba genes and cultural traditions identify ancestral roots in Jewish populations. The Lemba languages, on the other hand, are more closely related to Bantu languages, like Xhosa (which uses tongue clicks), than they are to Hebrew. Linguistically, the Lemba are solidly South African, even while the paths of their cultural and genetic histories lead to different continents. However informative any one of these evolutionary histories may be, it can only provide a glimpse of the immense diversity inherent in any human population.

Give Me an Example of That

Want more examples of homologies? Check this out:

- **Striking similarities**. We have seen that homologies can crop up in surprising places. The words you use to count to ten are homologous to numerals in other languages, just as your finger bones are homologous to bones in the wings, paws, and fins of many other species. But that is not all. The concept of homology can be applied to the genes in your DNA and even aspects of behavior. This short article from the Understanding Evolution website takes a look at five examples of homology, including structural, genetic, and behavioral examples: http://evolution.berkeley.edu/evolibrary/article/homology_01.

Branch Out

Visit the Understanding Evolution website to explore ideas related to key concepts from this article.

- The concept of VIST—variation, inheritance, selection, and time—can help us understand long-term change in many different situations: from the shift in body size in a population of heavily netted fish to the divergence of languages. Even within biology proper, this concept operates at many different levels. The cell lineages within an individual organism evolve through this process, as some lineages out-compete others and may inappropriately take over—much to the detriment of the individual made up of those cells. In the same way, large clades of species may evolve, with some groups becoming particularly diverse simply because they have traits that make them prone to speciation. Learn more online: http://evolution.berkeley.edu/evolibrary/article/selectionhierarchy_01.
- We have seen that biological and cultural evolution operate through many of the same processes but that they need not parallel one another exactly. In many cases, these two sorts of evolution even prod one another in new directions. The biological evolution of humans' ability to digest milk as adults (lactose tolerance), the biological evolution of wild aurochs into domesticated cattle, and the cultural evolution of dairying skills are historically intertwined—as well as fascinating and relevant to your students' everyday lives. Learn more online: http://evolution.berkeley.edu/evolibrary/news/070401_lactose.

Dig Deeper

Visit Understanding Evolution online to find out even more about some of the concepts addressed here.

- How natural selection works: http://evolution.berkeley.edu/evolibrary/article/evo_25
- How genetic drift works: http://evolution.berkeley.edu/evolibrary/article/samplingerror_01

In the Classroom

The broad applicability of the VIST concept can help your students recognize both the logic that underlies evolutionary theory and the power of the theory for helping us understand many different sorts of phenomena. High school students can analyze different evolutionary situations and identify the components of VIST within them. For example, you could challenge your students to read the following articles and they identify and explain the variation, inheritance, selection, and time that underlie the central evolutionary phenomena in each:

- From the origin of life to the future of biotech. The artificial selection of useful RNA molecules: http://evolution.berkeley.edu/evolibrary/article/ellington_01
- Evolution within. The evolution of cancer cells within an individual patient: http://evolution.berkeley.edu/ evolibrary/news/071001_cancer
- Angling for evolutionary answers. The evolution of smaller body sizes in fish as the result of human fishing practices: http://evolution.berkeley.edu/evolibrary/article/conover_01

Students at lower levels, who might not yet be ready to integrate variation, inheritance, selection, and time, can develop understandings of individual VIST components. Learn more about this teaching approach:

- Focus on the fundamentals. http://evolution.berkeley.edu/evosite/Lessons/IFundamentals.php#

Acknowledgments The author wishes to acknowledge Mark Pagel and Judy Scotchmoor for helpful comments on earlier drafts.

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