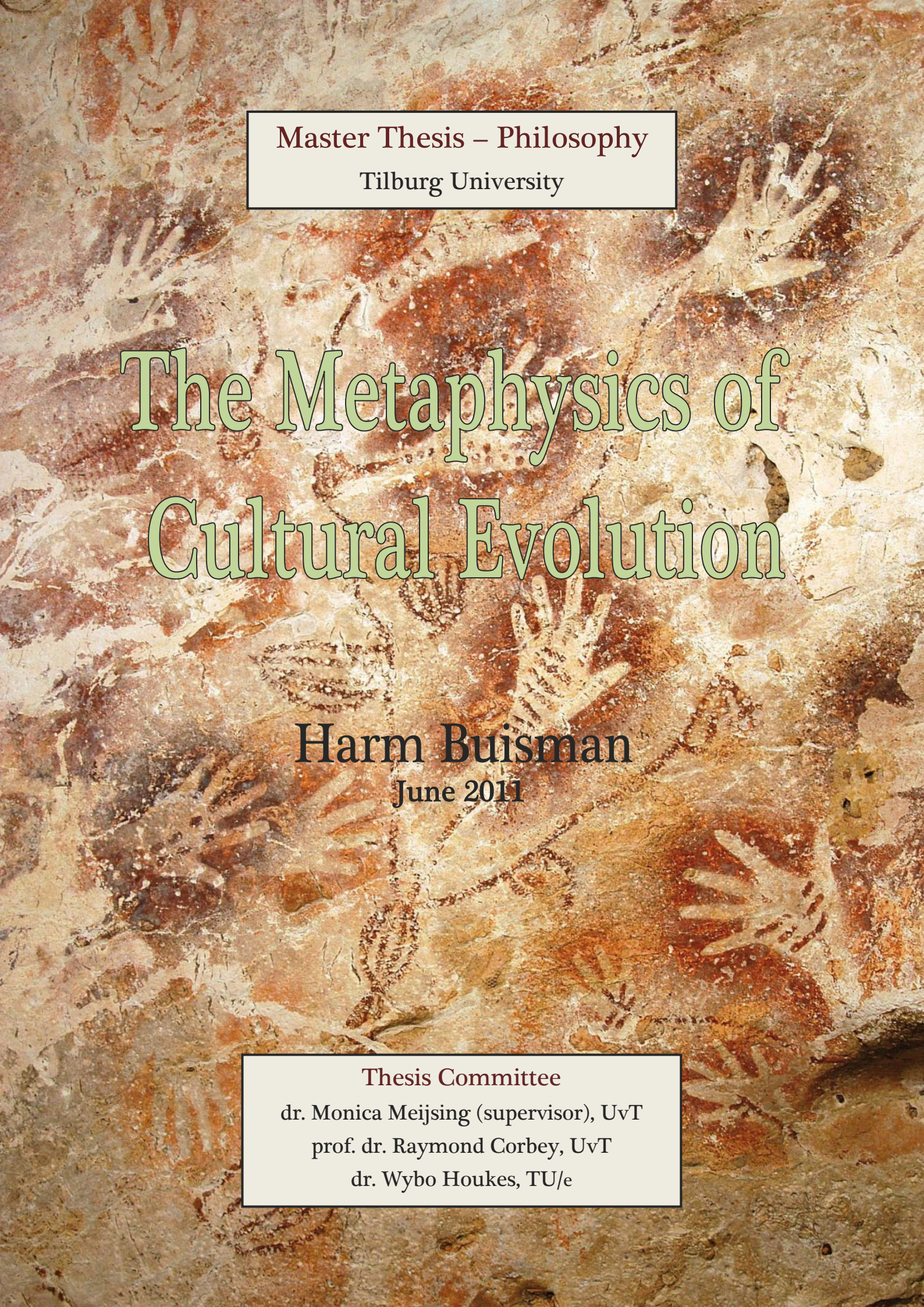


Master Thesis – Philosophy

Tilburg University

The Metaphysics of Cultural Evolution

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June 2011

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"Man with all his noble qualities, with sympathy which feels for the most debased, with benevolence which extends not only to other men but to the humblest living creature, with his god-like intellect which has penetrated into the movements and constitution of the solar system - with all these exalted powers- Man still bears in his bodily frame the indelible stamp of his lowly origin."

Charles Darwin (1871, p462)

Cover image: Luc-Henri Fage, "Tree of life" - Gua Tewet, Borneo

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Introduction

What is it to be human? People have pondered over this question for ages. Even though our intellects are unsurpassed in nature, Charles Darwin showed us that we share our ancestors with other animals; we are a product of evolution. It is our bodies that remind us of this common descent. Still, we are fundamentally different from animals. Our behavior is not determined merely by instincts that are biologically innate; we can adopt new behavioral repertoires. What we have and (other) animals lack is culture.

The most common conception of culture points us to cultural differences between groups of people, most notably between spatially separated groups. We for example easily see that the Asian culture is different from ours. But why are there so many different cultures? This question shows great similarity to a question asked about 150 years ago by Darwin, who wondered why there are so many different species. In his book *On the Origin of Species* (1859) Darwin shows that it is an algorithmic evolutionary process called natural selection that can explain the diversity of life, giving rise to the most important and heavily discussed biological concept of all time: the theory of evolution. In analogy we can argue that the diversity of culture is the result of a similar algorithmic evolutionary process; all of culture is the result of (and subject to) a process called cultural evolution.

In this work I seek to reveal the fundamental nature of cultural evolution; I aim to formulate the metaphysics of cultural evolution. In order to formulate this metaphysics I take three steps, which are respectively worked out in the three chapters of this thesis.

In the first chapter I analyze biological evolution and its metaphysical foundations. I work out Darwin's theory of natural selection and how the historical change in life forms can be visualized in a tree of life. I discuss the philosophical problems with the concept of the species and the concept of the gene. After an introduction into genetics I discuss the important philosophical problem: what is the unit of evolution? In answering this question I focus on the ideas of Richard Dawkins, who in his book *The Selfish Gene* (1976) introduces the concept of replicators. I conclude the chapter by investigating the processes of evolution itself.

In the second chapter I discuss two evolutionary accounts of evolution, two fields of research that apply Darwinism to culture. The first is memetics, which is a field that originated with Richard Dawkins' idea that replicators can also be found in culture, namely as memes. I give an overview of memetics using Susan Blackmore's book *The Meme Machine* (1999). The

second evolutionary account of culture is the domain of gene-culture co-evolution, also called dual-inheritance. I present its ideas by discussing the theory worked out in the book *Not by Genes Alone* (2004) by Robert Boyd and Peter Richerson. I conclude the chapter with a comparison between the two evolutionary accounts.

In the third and final chapter of this work I formulate the metaphysics of cultural evolution. I start by defining the scope of the metaphysics after which I investigate whether the distinction in biological evolutionary theory between genotype and phenotype can be used in cultural evolution. This requires close analysis of the use of concepts in memetics and gene-culture co-evolution. I conclude that it is philosophically necessary to make the distinction between cultural genotype and phenotype and that the meme is an element of cultural genotype. In the second part of the chapter I analyze what could be the physical instantiation of the meme and discuss how brain patterns are good candidates. In the third part of the chapter I explain how central dogmas of memetics and gene-culture co-evolution can be explained using the metaphysical framework that is proposed. I finish the chapter with two worrying implications of taking the meme perspective, namely that it suggests we have no free will and that some of the memes that determine our behavior are actually bad for us.

Chapter 1: Biological Evolution

This first chapter is about biological evolution with its many philosophical implications. I start with the single most important theory: Darwin's theory of natural selection. I link this to what triggered Darwin's research in the first place, namely the diversity and relatedness of life forms. I present the idea of the tree of life and its use in understanding the process of evolution. This also involves the classification of life into species. I highlight the philosophical problems with such a concept. In the second section of this chapter the focus is on the concept of the gene and the related science called genetics. I discuss the history of the concept of the gene along with its philosophical implications. The ideas of the species and the gene point to the problem are discussed in the third section of this chapter, namely the question of what actually is the unit of evolution, the entity that makes evolution possible. Central in this third section is the idea of the replicator as introduced by Richard Dawkins, who argues that it is the gene that is the unit of evolution. The fourth section of this chapter is about evolutionary mechanisms that determine survival, reproduction and creation of genes, organisms and populations. I end the chapter with a conclusion and bridge to the next chapter.

1.1 Darwin's theory of natural selection

Evolution means unfolding; it is a gradual process of change. Its most well-known use is in biology, where evolution is the change of life over time. The purpose of evolutionary theory is to explain this change. Jean-Babtiste Lamarck was the first evolutionary theorist who stated that change in the organic world happens according to laws and not by miracle. His ideas and the way he shaped his theory are the basis for contemporary evolutionary thinking (Gould 2002). Lamarck is however most widely known for his theory of inheritance of acquired characteristics. Lamarckism, as his theory is called today, holds that physiological changes acquired over the life of an organism may be transmitted to offspring. It was however proven to be false.

The most important theorist on evolution is Charles Darwin. He changed the world with his book *On the Origin of Species* in which he presented the theory of natural selection to explain why there are so many different species (Darwin 1859). The theory was accompanied by extensive empirical research. Though Darwin was not correct on all his claims, he for example accepted a measure of Lamarckism, his theory of natural selection is undisputed in the scientific community (Korthof 2010). In short, natural selection holds that in a diverse

population undergoing a struggle for life, individuals that successfully reproduce pass their characteristics on to the next generation. Individuals with characteristics that increase their chances of reproduction have a higher chance of passing on their characteristics, causing these characteristics over time to become more dominant in the population. Three elements are commonly taken as essential for natural selection to occur: *variation* of traits, *heritability* of these traits and *differential reproduction*, the difference in reproductive probability ensuing from the difference in traits (Brandon 2008). I would like to specifically add a fourth element, which is *scarcity* of resources[1]. This was already recognized by Darwin since it is scarcity of resources that leads to competition.

The beauty of Darwin's discovery of natural selection is highlighted by Daniel Dennett in his book *Darwin's Dangerous Idea*: natural selection explains how to create "Design out of Chaos without the aid of Mind" (Dennett 1995, p50). Via a simple non-intentional algorithm, nature creates design and complexity. According to Dennett this is Darwin's strange inversion of reasoning, which was already appreciated in the 19th century: "in order to make a perfect and beautiful machine it is not requisite to know how to make it" (Dennett 2009, p10062, original quote: MacKenzie 1868). Phrased differently by Richard Dawkins: "Natural selection .. has no foresight" (Dawkins 1986, p5).

Evolution thus has an algorithmic character, but what does this mean? Dennett ascribes three characteristics to algorithms: substrate neutrality, mindlessness and guaranteed results (Dennett 1995). Substrate neutrality means that an algorithm is a process of logical rules of which its success does not depend on the exact material or medium used in its instantiation. Mindlessness refers to the execution of the algorithm. An algorithm is like a recipe that is broken up in steps that do not require any decisions by a mind. The steps are executed automatically. The characteristic of guaranteed results refers to the fact that if the algorithm is executed without a misstep, the algorithm always produces the same result (given the same input). Darwin's idea that all the fruits of evolution can be explained as the products of an algorithmic process is according to Dennett Darwin's beautiful, but dangerous idea. It is dangerous because mankind was (and perhaps still is) not prepared for this insight.

[1] It can be shown with a simple computer model that without scarcity of resources the less fit characteristics become less dominant in the gene pool, but are not removed since total population can be of infinite size. With scarcity of resources the less fit characteristics are removed after a finite number of generations.

The tree of life

The diversity of life was a domain of interest long before Darwin. Already in the time of Aristotle did people try to bring order into the diversity of life by naming and classifying species in hierarchies. This is the field of taxonomy, which since Darwin is heavily informed by phylogenetics, the study of evolutionary relatedness among groups of organisms. There are two approaches to find this relatedness: either by morphological analysis of observable traits (phenotype), as was the approach Darwin used, or by molecular sequencing of genetic material (genotype, DNA). The historic path of evolution that resulted in the relatedness can be visualized in a phylogenetic tree, also called a tree of life. In its simplest form one can think of a family tree.

The very possibility to organize relatedness of life by morphological or molecular similarities in a phylogenetic tree alone provides evidence for evolution. Since Darwin, many morphological traits have been used to show evolutionary related ancestry between species and with the advent of molecular diagnostics, evidence for evolution is so overwhelming that we can consider evolution a fact. The tree of life should therefore not just be seen as a construct, but as a representation of evolution itself. Finding the 'real' tree of life is however not easy. One of the reasons is that we only have access to a select dataset, consisting of contemporary organisms and genetic and morphological material from fossil records.

For Dennett, the tree of life is a representation of the path of evolution through Design Space, the vast conceptual space of all possible paths that evolution might go, or might have gone under all different (starting) conditions. Dennett also works out that not every imaginable evolutionary result is possible. As genotype is discrete, as we shall see later, a single change in genotype could produce a large change in phenotype. The imaginary intermediate phenotype (in between the new and the old phenotype), might not be available and thus biologically impossible. Dennett defines biological possibility as follows: "*x* is biologically possible if and only if *x* is an instantiation of an accessible genome or a feature of its phenotypic products" (Dennett 1995, p118). What this also tells us is that biological evolution need not be gradual but can occur with leaps.

Opponents of evolution sometimes use the argument of complexity, saying that it is very unlikely that a complex organism or structure like the eye evolved without there being a designer. The invocation of a designer does not help the scientist, because this creates more problems than that it solves; what for example is the cause or origin of the designer? The scientist seeks to find a causal physical explanation for all phenomena; miracles are not

acceptable. That is why Darwin's theory is so important for science. Darwin showed that evolution is a cumulative process, in which design (understood as the product of evolution) builds further on design. At some points in evolution, evolution seems to jump a higher level of complexity. Ascribing the complexity not to the cumulative effect of evolution but to a designer would be invoking a skyhook, a miraculous step. This is exactly the error that people make when they bring up the complex eye argument. Eyes did not evolve *ex nihilo*, but are the result of an evolutionary process with many intermediary states, each providing some benefit over the previous one. Dennett explains evolutionary jumps that seem miracles via the analogy with cranes. Cranes, in evolution, are the tricks of evolution to speed up the exploration and opening up new regions of Design Space (Dennett 1995). Examples of cranes are the eukaryotic revolution, sexual reproduction, reinforcement learning and genetic engineering.

Another interesting observation by Dennett is what he calls a forced move. This refers to the observation that some design features are produced by evolution over and over again, because for some reason there is just one (preferred) way something can be done. In evolutionary theory this is known as convergent evolution, the acquisition of the same biological trait in unrelated lineages. An example is the wing in birds and bats. Though their common ancestor did not have wings, the wing in both species is similar in construction. This forced move towards similar wing structure can be understood as caused by physical constraints imposed upon wing shape[2]. The physical laws of the universe thus seem to bring with them forced moves in evolution. One could wonder if evolution would come to the same result if it was re-wound and played again. Gould argues that life would look different (Gould 1989). However, even if we disregard that the universe might be deterministic (which would mean that given a certain starting state all following states are fixed), then convergent evolution could be an argument for life being exactly (or at least very similar) as it is today (Conway Morris 2005).

Species

Talking about a struggle for life or a tree of life suggests that it is life that is our subject of interest. What exactly is meant by life is however not as straightforward as it seems. We could define life as a characteristic that distinguishes objects that we consider living from those that we do not (Weber 2008). See for example the following definition of living organisms that Weber refers to:

[2] Though part of the similarity must also be ascribed to the shared ancestry itself, since the wingless common ancestor was the starting position for both evolutionary trajectories.

> "Living organisms are autopoietic systems: self-constructing, self-maintaining, energy-transducing autocatalytic entities", but they are also "systems capable of evolving by variation and natural selection: self-reproducing entities, whose forms and functions are adapted to their environment and reflect the composition and history of an ecosystem" (Harold 2001, p232).

In the first part the characteristic of life is ascribed to an organism, but the second part of the definition speaks about evolution, which cannot be ascribed to a single organism, but only to at least two generations of organisms. To what concept of life can this ability to evolve be ascribed? Most people would find it intuitively acceptable to give species as an answer.

As Darwin presented it, evolution is indeed the process in which a species adapts to its environment. If enough adaptation accumulates, the result could be a new species. When this results in a branching lineage on the tree of life, this is called speciation. How exactly a species is defined is however troublesome. A common definition of species is a group of organisms capable of interbreeding and producing fertile offspring. This supposes a transitive relation. There is however a phenomenon called ring species, where a connected series of neighboring populations can interbreed with populations close to them, but the populations furthest away cannot interbreed with each other. A classic example is the circumpolar species of the gull genus Larus. Ring species show that the possibility of interbreeding is not a transitive relation. Another problem with this definition of species arises when one wants to assess if two organisms of the same sex belong to the same species. Of course interbreeding is implicitly defined as breeding between opposite sex, but what if interbreeding success is also dependent on which of the two is the female? That this is not a misplaced question follows from the phenomenon that when one crosses a (female) horse with a (male) donkey, all males are infertile, yet some females are fertile. Species are thus not well-defined. That species boundaries are vague shows the imposed character of the concept.

We can thus ask whether species are real. This is called the species problem. Darwin already called species indefinable, as the process behind speciation is the same process that causes varieties within a species: "I look at the term species as one arbitrarily given for the sake of convenience to a set of individuals closely resembling each other, and that it does not essentially differ from the term variety" (Darwin 1859, p87). Yet, we *do* use the concept of species. Taxonomists work from the idea that species can be distinguished based on a set of traits that are shared by all individuals of the species. The realistic account of species assumes that the distinction between species is naturally given, implying species are natural kinds that

can be understood as classes which can function in scientific laws true at any time and any place. This essentialist view was prominent before Darwin and already propagated by Aristotle. The account however requires a strict boundary between kinds, while species boundaries are vague (Hull 1965). A better way of viewing species might be viewing them as individuals. Contrary to natural kinds, individuals consist of parts that are spatiotemporally restricted (Ghiselin 1974 and Hull 1978). An organism then belongs to a particular species only if it is appropriately causally connected to the other organisms in that species. The organisms of a species must be part of a single evolving lineage. Species then are genealogical lineages, groups descendent from a common ancestor (Ereshefsky 2010). This view does however not solve the problem. Even when we look at lineages, it is a decision of the taxonomist where one lineage or a species begins and the other ends. There thus seems to be some basis for a nominalist perspective on species. I do think however that in scientific practice we should strive for the realistic account, even if species boundaries are not strict. It after all is the variation of life that caused us to distinguish between species, not the other way around. With Darwin's theory we can make more sense of the concept of species in evolution. We speak as if species adapt to the environment and with the definition of species as a lineage, it makes sense to do so. A definition of species that captures this idea is species as populations of organisms that carry a variable pool of inherited information through time (Boyd & Richerson 2000). A philosopher must however keep in mind that species are not natural kinds, and that a species is not an entity given by nature. Rather it is an entity that receives its meaning because there is a scientist ascribing properties to it. Also in biology, Kant's Copernican Revolution is relevant (Kant 1781). As philosophers, and scientists, we should be on guard when we speak about categories or entities as if they were given by nature itself.

1.2 Genetics

When Darwin formulated his theory of natural selection, he had no proper unit of heredity (Dennett 1995). Nowadays DNA is commonly accepted in science as the vehicle of evolution. Simply said, reproduction involves copying the DNA of the parents to the offspring, forming the blueprint for the new organism. In various organisms, humans included, the genetic material is coded on several pieces of DNA, the chromosomes. We have 23 pairs in every non-reproductive cell of our body. From each pair, one chromosome comes from our mother and one comes from our father. When our body creates reproductive cells (sperm or egg cells), one of each pair is selected in a stochastic process that is also called *random sampling*.

This means that there are 2^{23} possible variations in reproductive cells based on chromosome selection alone. A process called *crossover* further increases this number. Crossover is a process in which there is a possibility that genetic material is exchanged between chromosomes of the same pair, such that neither of the chromosomes is exactly the one we received from our mother or father. This creates diversity in populations. We can now understand why Dennett calls sexual reproduction a crane; it allows for rapid exploration of Design Space, by reshuffling genotypes with each generation.

It is the study of inherited traits that eventually led to modern day genetics, the science of the genes. Genetics however never provided one generally accepted definition of the gene (Rheinberger & Müller-Wille 2009). I now proceed to give a historical account of the different perspectives on the concept of the gene by following the line that was set out by Rheinberger and Müller-Wille in their contribution to the *Stanford Encyclopedia of Philosophy* (2009).

Classical genetics

In the nineteenth century Gregor Mendel (1822-1884) laid the foundation for modern day genetics. Mendel was the first to show, with his research on genetic traits of pea plants, that inheritance of traits followed particular laws (Mendel 1865). These laws were later called Mendel's laws of inheritance. Mendel's work was however not taken up until the beginning of the twentieth century when the term genetics was introduced by William Bateson in 1905 and distinction between hereditary space on the one hand and physiological and developmental space on the other hand was named genotype and phenotype respectively (Johannsen 1905). With this distinction, Wilhelm Johannsen coined the element of genotype to be the gene.

The concept of the gene became successful as it proved to be a productive instrument in developmental and evolutionary studies (just as the concept of species is productive in taxonomy). In fact, evolution was redefined as the change of gene frequencies in the gene pool of a population. This integration of genetics and Darwinian evolution is called the modern evolutionary synthesis (Huxley 1942). The concept of the gene was assumed to have its material counterpart in reality, and with this transition two fundamental properties of genes were postulated: autocatalysis and heterocatalysis (Morgan e.a. 1915). The autocatalytic function of genes represents their character as units of transmission that reproduce and thereby connect the genotypes of successive generations, while errors in replication potentially give rise to new genotypes, a process that is called mutation. The heterocatalytic function represents the role of genes as units of function in the expression of traits, the

phenotype. Without scientific knowledge of its material nature however, the gene remained a conceptual idea, although research successes based on the concept having its counterpart in reality strengthened the belief in the gene as a discrete material entity.

Molecular genetics

With the advance of technological methods, DNA as the bearer of our genetic information could be studied in more detail. Francis Crick and James Watson showed in 1953 that DNA was structured as a double helix with discrete pairs of four bases, adenine (A), thymine (T), guanine (G) and cytosine (C). Via complicated molecular replication processes, DNA is duplicated and transmitted into new-grown cells. The autocatalytic function to be expected from a hereditary entity seemed to be discovered in DNA and its replication machinery. This is however problematic for the view of the gene as a self-replicating unit, since the autocatalytic property lies in the DNA (and its replicatory mechanisms) at large.

With these new molecular insights, DNA was understood as a gigantic string of discrete information packets or code. It turned out that parts of the code can be interpreted by molecular mechanisms and used for the production of proteins. This occurs via an interpretation-key of triplet coding in which any sequence of three bases (A,T,G and C) maps to one specific amino acid[3], the building block of proteins. The genetic code, along with its molecular interpretation mechanisms, is (nearly) universal for all life. This triggered the idea of the gene as a stretch of DNA carrying the information for the assembly of a particular protein. Investigation into the mechanisms of assembly of proteins showed that DNA has two more functions built-in: regulation and signaling. The parts of the DNA with the information how to build a protein are called structural genes, while specific parts, the regulatory genes, regulate the expression of the structural genes. The signaling function of parts of our DNA is to signal molecules involved in the assembly of proteins where on the DNA to bind. This view of the functioning of DNA in which the genotype is viewed as an ordered hierarchical system or genetic program is called the operon model. Interestingly, in order to execute the program, its own products are needed.

Via the assembly of proteins, DNA and involved processes can be understood as having a heterocatalytic function. The operon model as described here is however a too simplistic account of the complex processes behind the expression of genetic information. It turns out,

[3] There are three triplet codes that actually code for the end of the protein rather than for an amino acid, these are called stop-codons.

for example, that a strand of structural DNA can be involved in more than one product and some products have more than one strand of DNA as the information source of its assembly. These complexities make it problematic to ascribe a heterocatalytic function to a single discrete material entity. The notion of a gene as the discrete material entity that has the property of both autocatalysis and heterocatalysis therefore seems to be untenable. In fact, some say that the gene is not to be seen as the unit of evolution, but rather as its product (Beurton 2000).

In their article Rheinberger and Müller-Wille (2009) seem to be giving up on the realistic account of the gene. They refer to instrumentalist explanations for the success of the gene. The reason genes still are popular as the determinants and executors of life could be understood from their role as investigative entities, rather than from their explanatory value (Weber 2004). The concept of the gene and the talk in terms of *a gene for* therefore seem to draw their success from an epistemic and pragmatic perspective, rather than from an ontological one (Gannett 1999). I however find both these accounts unsatisfying, since there is no doubt about there being a material entity representing genotype.

In its common use the gene is not even central, the phenotype is. This requires a short intermezzo: we can talk about the gene *g* for phenotype *p*. When there are multiple variants of *p*, each variant is called an allele. If an organism has the same allele on each of our chromosomes on which the gene resides it is called homozygote, if it is different it is called heterozygote. In this use, the term gene seems to point to the slot for the alleles, rather than to a fixed material entity. In other uses we call an allele a gene. Though the gene as an isolated entity that conducts both autocatalysis and heterocatalysis seems untenable, it is clear that the material to which we refer as gene is very real. I would define this entity to hold two characteristics: it is heritable and it is causally necessary (though not sufficient) in the expression of a certain phenotype. Which parts of our DNA and biochemical machinery we consider to be *the gene* for a specific phenotype remains, as in taxonomy, a matter of classification. Just as with the concept of the species, the gene is linked both to reality and to the subjective act of knowing.

The gene thus has various definitions. This multitude in concepts of the gene comes from a multitude in ways to look at the reproductive machinery of life, where the gene is used for similar, but not identical entities. Each concept can be instrumental for the perspective, yet what we are interested in here is the fundamental element of evolution. Whether this is the gene (in one of its definitions), the species or some other entity is the topic of the next section.

1.3 Levels of selection

In this section I seek to answer what the unit of selection is from within the process of evolution. Since Darwin, the species has been considered as the unit of evolution, but in his book *The Selfish Gene* (1976) Richard Dawkins makes the case that the true unit of evolution is the gene. In this book he criticizes any form of group selection (e.g. species selection) and the view that the organism itself benefits from natural selection. A unit of selection is in Dawkins' words an entity "that survives, or does not survive, as a consequence of natural selection" (Dawkins 2006, page viii). Before I go into specifics I want to highlight that I used two terms: the unit of evolution and the unit of selection. Whether these mean the same depends on what is meant by evolution and selection. In an extensive discussion of the "unit of selection" debate, Elisabeth Lloyd argues that there are four important questions that are often confused (Loyd 2005): What units are being selected actively in a process of natural selection? Which organic entities meet the definition of the replicator (defined below)? Who benefits from a process of evolution by selection? And finally, at what level do adaptations occur? I now proceed to work out Dawkins' account of the debate, after which I evaluate in which way these four questions can be answered.

Replicators

In *The Selfish Gene (1976)*, Dawkins invites us to look beyond life, before life as we know it today was created. Darwin did not venture there, even though the title of his book suggests otherwise. Darwin started where species were already a given (Dennett 1995). Natural selection does however not depend on the substrate. Life therefore is not required for evolution. According to Dawkins, the first form of natural selection was in fact the selection of stable molecules and the rejection of unstable ones. As this process continued, "at some point a particularly remarkable molecule was formed by accident. We will call it the *Replicator*. It may not necessarily have been the biggest or the most complex molecule around, but it had the extraordinary property of being able to create copies of itself" (Dawkins 1976, p15). This replicator was not alone, it had to compete for resources with other replicators, and an arms race was the result. Dawkins theorizes that the success of a replicator depends on three characteristics: longevity (a longer existence increases the chance of replication), fecundity (a replicator must be replicated at a high enough rate) and fidelity (replication must be accurate). At some point replicators that survived built themselves survival machines, called vehicles, to reside in. This process continues, where today (according to Dawkins 1976) genes are the replicators and organisms are the vehicles. Later,

Dawkins uses as a definition for a replicator "anything in the universe of which copies are made" (Dawkins 1982a, p83) and for a vehicle "any unit, discrete enough to seem worth naming, which houses a collection of replicators and which works as a unit for the preservation and propagation of those replicators" (Dawkins 1982a, p114).

David Hull distinguishes two ways replicators interact with their environment: "they produce copies of themselves, and they influence their own survival and the survival of their copies through the production of secondary products that ultimately have phenotypic expression" (Hull 1980, p318). Hull calls the entities that function in the second role *interactors*. The interactor interacts as a cohesive whole directly with its environment, thereby making replication differential. Dawkins' vehicles can be considered to be interactors, the entities on which selection acts directly: "Most of the replicator's phenotypic effects are represented in the vehicles, which makes the vehicles the proximate targets of natural selection" (Dawkins 1982b, p62). However, Dawkins does not consider them to be the units of selection, as the characteristics they acquire are not passed on. There is a causal arrow from replicator to vehicle, but not the other way around (Dawkins 1982a). Note also that Hull introduces the characteristic of autocatalysis in his definition. This is absent in the definition of Dawkins. In fact, Dawkins' definition allows vehicles to copy replicators. In this work I use Dawkins' definition of the replicator, because, as we saw earlier, the characteristic of autocatalysis cannot be ascribed to a single gene, but only to DNA (or perhaps even the whole vehicle) at large.

For Dawkins, it is the replicator that is the true unit of selection, because it is the only unit that survives the selection process. Organisms, groups, populations, and even genomes are destroyed during selection and reproduction. Note however that replicators survive in a qualitative way, not in a numerical way, since strictly speaking it is the copies of the replicators that survive (Loyd 2005).

Genes as replicators

The definition of the gene Dawkins uses is "any portion of chromosomal material that potentially lasts for enough generations to serve as a unit of natural selection" (Dawkins 1976, p28). This excludes the whole genotype in species that have sexual reproduction, since with every generation, the genotype is renewed (Dawkins 1982b). Competition takes place even at the level of the genes; the alleles of a gene are in competition for their slot on the chromosomes of future generations. The gene therefore is the basic unit of selfishness. For Dawkins the existence of non-coding DNA is proof that the true 'purpose' of a gene is to

survive for itself, "no more and no less" (Dawkins 1976, p45). These non-coding genes are free riders, riding the vehicles created by functional DNA (Dawkins 1976).

For the gene the environment consists largely of other genes, the fitness of each being determined by its ability to cooperate with the other genes in its environment. After all it is the vehicle, a product of cooperating genes, that is the proximate target of selection. If a vehicle is destroyed, all replicators inside it are destroyed as well (Dawkins1982a). Dawkins therefore calls us humans (or any other organism) gigantic colonies of symbiotic genes. In his book *The Extended Genotype* (1982), he makes a further distinction between *germ-line replicators* and *dead-end replicators*. The first is "potentially the ancestor of an indefinitely long line of descendant replicators", while the second may be copied a number of times, but is "definitely not the ancestor of an indefinitely long line of descendants" (Dawkins 1982a, p83). Germ-line replicators are genes in a gamete (a reproductive cell), genes in those cells that are the ancestors of gametes or genes in single cell organisms. Dead-end replicators are most of the DNA molecules in other cells of our body, for example those in our hair. Since it is the germ-line replicators that "live on", they are the true unit of selection; they are the units that benefit from adaptations.

A specific gene can have copies in different vehicles, for example in another vehicle that is a relative of the host organism. For Dawkins this can be the only true reason why a selfish gene would cause its host to express altruistic behavior. In fact, every valid form of group selection is according to Dawkins kin selection, the idea that selfish genes help their copies in related organisms. That in some species individuals act altruistic is according to Dawkins the result of the fact that in small populations, another individual in that population can expected to be kin, and thus helping the other individual at some cost to oneself helps the selfish genes. Dawkins considers that even a group of organisms can be considered a vehicle (Dawkins 1982a). One could question if this does not open the door for group selection. However, even if a group can be a proximate target of selection, "it is still genes that are regarded as the replicators which actually survive (or fail to survive) as a consequence of the (vehicle) selection process" (Dawkins 1982a, p115). Groups are not discrete enough to be a unit of natural selection, due to constant blending with other populations and internal evolutionary change (Dawkins 1982a).

The four questions

Let us now try to answer the four questions Loyd formulated. The first question is: What units are being selected actively in a process of natural selection? It is the vehicles that interact with

the environment, making them the proximate targets of selection. There is however no causal arrow from vehicles to replicators, meaning that change adopted by vehicles is not transmitted to the next generation; only the replicators survive. What is thus selected are the replicators, be it via a vehicle-mediated process of selection.

The second question is: Which organic entities meet the definition of the replicator? According to Dawkins a replicator is anything of which copies are made. For Dawkins (in biology) this can only be the gene. The gene itself he defines as any portion of chromosomal material that potentially lasts for enough generations to serve as a unit of natural selection. Note that this stretches the definition of the gene beyond what we normally use the concept of gene for; gene could be used for a set of chromosomal material that holds genes for multiple traits.

The third question is: Who benefits from a process of evolution by selection? It is the replicators that survive in the evolutionary process, so replicators are the beneficiaries of evolution for Dawkins. More specifically it is the germ-line replicators that benefit since opposed to dead-end replicators, they can potentially be the ancestor of an indefinitely long line of descendants. Note that this question is *ex post*, not *ex ante*. Evolution does not occur for the benefit of the replicators; it is not a teleological process with replicator survival as its goal. Rather it is a process in which replicators turn out to be the beneficiaries. I stress this, since sometimes authors make statements of the form "*p* exists for the benefit of replicator *r*", a language construct that can easily be misunderstood as suggesting teleological causation.

The final question is: At what level do adaptations occur? This is a bit harder to answer from Dawkins' perspective. Adaptation implies change. We could reformulate this question as: which entity is changed in order to provide a better fit with the environment? If a replicator is changed, it is by definition no longer the same replicator, thus the level of the (single) replicator cannot be the level of adaptation. Is it then the vehicle that is the level where adaptation occurs? This seems wrong, since we just discussed that vehicles cannot propagate change to the next generation; any change that is persistent over the generations has to come from the replicators in the vehicle. For the individual replicator, other replicators and the vehicle it resides in make up its environment. Suppose now an individual replicator that has copies in various vehicles. Since its co-replicators vary, leading to differential reproductive success, only some of the vehicles survive. What remains is a new set of vehicles that seem more adapted to the outside environment (outside of the vehicle). It is the genotypic environment of a gene that seems to adapt to the outside environment. Since the genotypic

environment codes for the vehicle, it is the vehicle which is the level at which adaptations occur. Interestingly, Dawkins considers vehicles to be any entity which houses a collection of replicators, meaning that a vehicle can be a chromosome, an organism, and even a population. Thus adaptations can occur at all of these levels.

Evolution or selection

In the beginning of this section I pointed to the confusing use of both "unit of evolution" and "unit of selection". Evolution I defined earlier as a process of change, in biology the change of life. I also discussed that classification of life into species or organisms and the classification of molecular objects into genes is at least partly subjective. If we ask the question about evolution of life, this implies a definition of life. The evolution of life could for example mean the evolution of a species. In this sense, the unit of evolution one is interested in is the species. The question then translates into the descriptive question: what changes did a species (e.g. homo sapiens) go through in time?

Evolutionary science does not stop there, it seeks also to explain and predict. The classifications we use to bring order into our reality, for example molecules, cells, organisms, social groups, populations, species, phyla, etcetera, can be structured in a hierarchy. An organism is a specific set of cells, a species is a specific set of organisms. To explain change at one level, it might be needed to look at processes at a lower level. Dawkins argues, that in the hierarchy of life, evolution at any level can only be explained by considering the level of the genes. Therefore no matter what is meant by life, evolution of life in its explanative and predictive use boils down to considering evolution from the viewpoint of the gene. It is the gene that as a replicator is the true unit of evolution. The unit of selection can either mean that which is selected, or that which is passed on in the process of selection. Dawkins uses the latter definition such that the unit of selection is also the replicator. Thus in Dawkins' terminology, the unit of selection and the unit of evolution are used as interchangeable concepts.

In the next section I discuss the mechanisms that affect which gene does or does not survive in the process of evolution.

1.4 Evolutionary mechanisms

Since in the modern synthesis, in the first half of the 20th century, genetics and Darwinian evolution were integrated, the field of evolutionary genetics attempts to account for evolution

in terms of change in gene and genotype frequencies. The field distinguishes four forces of evolution, each with its own effect on the gene pool of populations: *mutation*, *random genetic drift*, *natural selection* and *gene flow*. According to evolutionary genetics, the micro-evolutionary patterns that occur at the level of the genotype due to these forces, in time give rise to macro-evolutionary patterns such as variation between species (Wade 2005). An important field of research for the modern synthesis is population genetics with Sewall Wright, John Haldane and Ronald Fisher as its founders. Population genetics studies allele frequency distribution and change under the influence of the four forces. It makes extensive use of statistics and mathematical models, which contributed to the understanding of evolutionary mechanisms.

Natural selection

Natural selection is the evolutionary force that was first postulated by Darwin. It causes adaptation, the fit between organism and environment, and conserves genetic states. It selects on phenotype, the expressed characteristics of the organism. The expressed characteristics after all determine how successful an organism is in an environment. As a result, the genotype of a successful phenotype becomes more common in a population. Natural selection also tends to remove variation, by removing the less fit allele from the gene pool. This homogenizing effect is called purifying selection, which can happen either by removal of the less fit allele from the gene pool altogether or by the fitter gene 'outbreeding' its counterpart.

The selective effect of genes depends on the environment; there is genotype-by-environment interaction. When the environment changes, for example due to climate change or migration, the selective effect of a gene could change as well. This possibility of change creates a trade-off between specialized adaptation to local conditions and generalized adaptation to global conditions. Too strict adaptation might thus be counterproductive. Culture, the topic of the next chapter, is evolution's adaptation that allows specialization without losing generalization.

Both Dennett and Dawkins stress that evolution is not a rational, intentional process. The struggle for life is the struggle of an organism to survive in its environment and reproduce. However, rather than a story of success, selection is a story of destruction. All organisms that are not fit enough, do not reproduce, and as a result the existence of the organisms' genetic material ends there. If this happens for all individuals in a certain species, the species becomes extinct. Within a species there is also variation in traits. The theory of natural selection tells us that those traits that increase success of survival and reproduction become more dominant. To an outside observer it seems as if species adapt to the environment, but the hard truth is that

natural selection is more like a pruning process, exterminating all life that fails to live up to the challenge[4].

Natural selection requires variation. Without genetic variation, there will be no evolution (Dawkins 1982a). Natural selection seeks to eliminate variation. What then creates variation? The answer is mutation.

Mutation

Mutation is the force that introduces new genetic variants in a population. Mutation can be caused by radiation, viruses, transposons (genes that change their genome location in a single cell), mutagenic chemicals and errors during DNA replication or meiosis. Strands of DNA affected by mutations can have different lengths, including point mutation (one base pair) and duplication of whole genes. Duplication is a major source for the evolution of new genes. The human eye for example uses four genes for the different structures to sense light (three for color, one for night vision), which all evolved from a single ancestral gene (Bowmaker 1998).

One specific type of mutation is horizontal gene transfer, the transfer of genetic material between species (versus vertical gene transfer as the ancestral parent-to-child direction). This is particularly the work of bacteria and viruses which can insert genetic material in the genetic material of their host. As mutations can cause damage to cells, DNA repair mechanisms evolved. The optimal mutation rate for a species is therefore a tradeoff between the adverse effects of mutations and the cost of DNA repair systems (Sniegowski e.a. 2000).

Gene flow and genetic drift

Gene flow is the interchange of individuals or breeding between populations, thereby limiting genetic divergence of populations. Gene flow thus has a homogenizing effect. This is a counterforce to random genetic drift, which creates genetic divergence. Genetic drift is caused by random sampling of the alleles of parents and stochastic effects in survival and reproduction. Genetic drift can lead to genetic divergence between isolated groups if via the random processes traits become extinct in one, but not the other group. Within a population it can remove genetic variants, reducing genetic variation in that population. The importance of genetic drift scales down with population size, as stochastic effects become smaller as the number of stochastic events increases.

[4] I recommend reading Kant's *Kritik der Urteilskraft* (1790). In this book Kant discusses that we understand nature as if it has a purpose.

Sexual selection

There is another evolutionary force that could be considered: sexual selection. This is however not unanimously accepted as an evolutionary force. Let us first investigate why. When diploid organisms (with two copies of each chromosome) reproduce by random mating, in the absence of the four evolutionary forces, the allele frequencies remain constant over time and the population ends up in an equilibrium distribution of genotype[5]. This result is called the Hardy-Weinberg principle (Hardy 1908, Weinberg 1908) and shows that sexual reproduction as such does not remove variation in a population. This changes when mate selection depends on traits of the organism. Organisms can choose mates that are similar to them, called positive assortment, or choose mates that are dissimilar, called negative assortment. A special case for the first is inbreeding, the mating with relatives. Non-random mating does not change the allele frequencies, rather it changes the genotype distributions (homozygotes versus heterozygotes). When organisms choose mates that are similar, the fraction of homozygotes increases with each generation, while when organisms choose dissimilar mates, the fraction of heterozygotes increases. In nature, choosing mates that are similar is more common, but since most deleterious alleles are recessive, the increase of homozygotes could result in reduction of the mean fitness of the population, an effect called inbreeding depression[6].

Population geneticists usually do not consider non-random mating as an evolutionary force, since (in the theoretical model) it changes the genotype but not the allele frequencies. This might be so if mate choice is viewed as mate similar and mate dissimilar, but if mate choice is dependent on specific traits, the genes for these traits can be under selective pressure. This is what is called sexual selection, and hence, analogous to natural selection, can be an evolutionary force. One could however also defend that in this case, sexual selection is a special case of natural selection.

Sexual selection was already proposed by Darwin to potentially lead to runaway processes. The common example of runaway evolution is the peacock's tail (Darwin 1871)[7]. These runaway processes are not necessarily 'errors of evolution'. In one theory, the feathers that

[5] Under the absence of evolutionary forces and with random mating, in a population with the frequencies p and q for the alleles A_1 and A_2 respectively, the frequency of the genotypes $f(A_1A_1)$, $f(A_1A_2)$, $f(A_2A_1)$ and $f(A_2A_2)$ in the population reaches the equilibrium distribution of respectively p^2, pq, pq and q^2.

[6] This explains why the incest taboo is fitness enhancing.

[7] Although I must note that critics tend to refer to an article that indicates no proof was found that the peacock tail influences attractiveness of the peacock (Takahashi e.a. 2008).

eventually lead to flying birds, were at first not meant to fly but for dinosaurs to impress potential mates (Barton 2005). Runaway processes can thus open up an unexplored area of Design Space. Many believe that our brain is the result of such a process of sexual selection, the size and organization of our brain a product of runaway selection, opening up the Design Space of culture for evolution to explore.

Relative contributions of the forces

A main topic of debate is the role each of these forces play in evolution. This is particularly so for the contribution of genetic drift versus natural selection, since both reduce genetic variation in a population. Researchers that follow the modern synthesis accept natural selection as the most important mechanism of change (Smocovitis 1996). Motoo Kimura, however, in what is known as the neutral theory of molecular evolution sees genetic drift as the main contributing mechanism for evolutionary change (Kimura 1983). The main claim of his theory, that the majority of permanent changes in DNA are selectively neutral, was proven wrong, although neutral theory does help in explaining some other evolutionary phenomena (Korthof 2009).

An argument against neutral theory is that increased mutation in non-functional genes. It has been shown that stretches of DNA that are non-functional, called pseudogenes, evolve faster than their functional counterparts. This follows intuitively from one of the prerequisites for natural selection: differential reproduction. A mutation in a non-functional gene usually does not introduce variation with differential reproduction, while in a functional gene, natural selection will purify the (often) adverse mutation from the gene pool.

With the mathematical models of population genetics it can be shown that the larger a population, the smaller is the effect of genetic drift. Also, when the selective effect of a gene on the fitness of the organism is higher, the effect of genetic drift is lower. Natural selection has the inverse relation for these parameters. Furthermore, there seems to be a relation with population growth. In periods of decline (for example due to increased scarcity of resources), natural selection is stronger than in periods of growth. As a result, genetic drift is sometimes viewed as irrelevant in a period of population decline, even if the population is small (Wade 2005).

1.5 Conclusion

This first chapter dealt with the philosophical aspects and complexities of biological evolution. Darwin's theory of natural selection, which allows us to understand evolution as an algorithmic process removed the Creator, a Mind, from the equation. In the words of Nietzsche: "God is dead" (Nietzsche, 1882). Natural selection requires just four elements: variation, heritability, scarcity and differential reproduction. It is substrate neutral; other processes with these elements are expected to undergo natural selection as well. One such process is cultural evolution, the main topic of this work.

In this chapter we saw that all life is connected through evolution, a connectedness that can be visualized by the tree of life. The relatedness of life due to the algorithmic process of evolution is problematic for an essentialist concept of species. Species are not natural kinds, but groups of individuals, for example a lineage with a common ancestor. Classification of life into a species is at least partly subjective. In daily (scientific) practice this is not problematic, but it makes us wonder what *does* define the nature of an organism if it is not its belonging to a species.

With the separation of genotype and phenotype after the modern synthesis, the gene came into the picture. I showed that the concept of the gene has its own history and problems. We can safely say that a gene is heritable and is causally necessary (though not sufficient) in the expression of a certain phenotype, even though there is no generally accepted definition of the gene. Genotype as causally necessary for an organism's traits (phenotype) suggests that the nature of an organism can be ascribed to its genotype; it is the genotype that carries the essence of the organism.

When we are interested in evolution, we are interested in the changes to life. We usually describe this in terms of (the change in or within) species. The question is however whether it is the species that is also the unit that drives evolution. In this chapter I discussed that Dawkins looked for the unit of evolution from within the process of evolution. Central in this discussion is the concept of the replicator, an entity of which copies are made, as opposed to the vehicle, that has a role to preserve and propagate the replicators residing inside the vehicle. In biology, we can consider genes to be replicators and organisms to be vehicles. The proximate target of evolution is the vehicle, since its traits determine whether its replicators survive and are reproduced. These traits are coded in the replicators, which thereby influence their own reproduction; there is a causal arrow from replicators to the vehicle. There however

is no causal arrow from the vehicle to the replicator. It is replicators that survive or do not survive in the process of evolution. Since genes are the replicators in biological evolution, it is the gene that is the true unit of evolution.

The analysis of evolution therefore involves understanding the mechanisms that determine which genes survive or do not survive. This is what population geneticists try to achieve; they describe evolution in terms of change in gene and genotype frequencies. As evolutionary mechanisms they distinguish natural selection, genetic drift, mutation and gene flow. It is the micro-evolutionary patterns that occur at this level that in time give rise to macro-evolutionary patterns such as variation between species.

In the next chapter I discuss two theories on cultural evolution: memetics, that originated from Dawkins' idea that culture is similar to biology and has its own replicators called memes, and gene-culture co-evolution, which also is based on the idea of culture having its own evolutionary path, but does not see cultural evolution in such strict analogy to biological evolution.

Chapter 2: Cultural Evolutionary Theory

Opposed to other animals, what we are is not just a matter of our biological evolution, in Dennett's words: "What we are is very much a matter of what culture has made us" (Dennett 1995, p340). In this chapter I discuss two fields that seek to explain cultural evolution from the position that culture evolves more or less independently from biology. These fields are memetics and gene-culture co-evolution. For memetics I focus on two authors: Richard Dawkins, who pioneered the meme-idea, and Susan Blackmore, who wrote a book on memetics called *The Meme Machine* (1999). Central in this discussion is the meme's-eye-view, a perspective that is taken in memetics to analyze all kinds of cultural phenomena, for example religion or alternative medicine. It is also from the meme's-eye-view that its central dogmas are derived. I end the section on memetics with a discussion of its criticisms and the response given to these criticisms by Blackmore. In the section on gene-culture co-evolution I focus on culture, not on genetics, which is the other major part of the field. In line with the book *Not by Genes Alone* (2004) by Richard Boyd and Peter Richerson I start by discussing the importance of culture and cultural evolution for understanding the behavior of people. After that I introduce the concept of the cultural variant. The focus of the section is on the evolutionary mechanisms that determine the dynamics of cultural variants in a population. It is also in this part that I state the central dogmas of gene-culture co-evolution. As in the discussion of memetics I end with criticism on the field and a response to this criticism (in this case by Laland and Brown). I end the chapter with a comparison between the two fields, discussing both their similarities and their differences.

2.1 Memetics

In the previous chapter we became acquainted with the concept of replicators and with genes as their biological instantiation. In *The Selfish Gene,* Dawkins wonders if genes are the only replicators (Dawkins 1976). No, he concludes, man is an unusual kind of animal. To catch his peculiarities we have to look at culture and culture has its own unit of transmission, the meme. According to Dawkins, memes spread via imitation leaping from brain to brain. Memes can be understood as units of imitation like "tunes, ideas, catch-phrases, clothes, fashions, ways of making pots or of building arches" (Dawkins 1976, p192). This idea resulted in the subject now called memetics. Memetics builds on a strong analogy between genes and memes. Just as genes need to survive in the gene pool, memes have to survive in the meme pool; natural selection acts just as well on memes as it does on genes. Memetic and

biological evolution are however separated. Dawkins argues against people that like the idea of memes and then reformulate the story as if memes are there for the benefit of genes. Just as genes, memes are selfish. They may often reinforce each other, but may as well be in opposition. As an example of the latter, Dawkins mentions celibacy, which is disastrous for biological reproduction of its host, but helps in the spread of religious ideas by freeing up the time the host has available for missionary work.

In *The Extended Phenotype* Dawkins sharpens his definition of the meme: "A meme should be regarded as a unit of information residing in a brain" (Dawkins 1982a, p109). What the meme is depends on how brains store information. Dawkins speculates that the meme could be a definite pattern of synaptic structure. A meme itself is not visible. It is the phenotypic effects, for example behavior, of a person that are visible. Dawkins considers two characteristics of biological replicators: they are copied and they have an effect on the outside world. The meme has both as well: it is copied via imitation and, via selection pressure by the environment, the phenotypic expressed behavior affects the meme's chance of transmission (Dawkins 1982a).

The Meme Machine

Dawkins pioneered the idea of memetics, but the most extensive overview of memetics comes from Susan Blackmore. In her book *The Meme Machine* (1999) Blackmore brings together most of memetic thinking up till then. Therefore I use *The Meme Machine* as the basis for the discussion of memetics. For Blackmore memes are "instructions for carrying out behavior, stored in brains (or other objects) and passed on by imitation" (Blackmore 1999, p43). According to this view, something can only be a meme if it is passed on by imitation. Behavior that cannot be passed via imitation is not a meme. Since only humans truly imitate, memetic transmission is exclusively human. Blackmore goes to some length to argue that social learning is not 'true imitation'. The reason (or the goal) for her refutation of social learning or what aspects of social learning she refutes remains unclear. Maybe she wants to keep the term as pure as possible, in its original form as when the meme was first defined by Dawkins as something which is passed on by imitation. It almost seems as if she protects the original meme for the meme-idea from mutation.

Just as genes are selfish, memes are selfish. This means that in order to understand the processes of evolution, according to memeticists, we need to take the meme's eye view: "the view that looks at the world in terms of opportunities for replication - what will help a meme to make more copies of itself and what will prevent it?" (Blackmore 1999, p37). Blackmore

(1999, p51) adopts the view that memes are replicators because "the form and details of behavior are copied" (heritability), "they are copied with errors, embellishments or other variations" (variation), and "only some behaviors are successfully copied" (selection). Later she suggests memes are in competition for settling in our brain (scarcity). Memes as replicators thus satisfy the four requirements for natural selection.

Successful memes

If memes are subject to natural selection, what then describes a successful meme? Sadly Blackmore gives us no structured answer to this important question. The reader needs to extract elements from several chapters and examples in order to give an overview as I proceed to do here. Blackmore has her own story of human evolution. At first there was selection for imitation. Being able to imitate gives the imitator an edge over people who do not imitate. The result is that human beings evolved to be good imitators. At least initially, the best memes are the memes that are best for the genes. As our psychology evolved for our bodies to get a reproductive edge, memes that have to do with sex, food and power tend to be successful memes. However, the timescale of genetic reproduction is much larger than that of memetic transmission. Since memes change often and fast, the synchrony between memes and genes gets lost and memes get on the loose. Our brains had to evolve heuristics such as "copy the most obvious memes", "copy the most popular memes" and "copy memes to do with food, sex and winning battles" (Blackmore 1999, p78). Finally, since memes guide our behavior, they can change selection pressures on genes. Memetic evolution can therefore lead to runaway effects. Blackmore suggests that at some point in evolution people started imitating the best imitators. It is however unclear from her story on what basis this happens. Are imitators successful and therefore imitated, or do people recognize a good imitator and just imitate whatever the imitator imitates? I find the first explanation more convincing, which is in line with the statement by Blackmore that from scientific research it follows that people are more often persuaded by others who are perceived as powerful or famous. Scientific research also shows we are more likely to be persuaded by someone we perceive as similar to ourselves or by someone we like. Major factors for liking include physical attractiveness, similarity, cooperativeness and the belief that the other person likes you. The reader can conclude that success of a meme is determined by the content of the meme itself, as well as by the characteristics of people who already carry the meme, with cultural selection being strongly mediated by our evolved psychologies.

Other memes can also influence success. Just as genes can have symbiotic relations with other genes, memes can support (or exploit) each other. In memetics these sets of interrelated memes are called memeplexes. The meme and memeplex are both replicators in the sense that they are under selective pressure and for most of the discussion it does not matter where the meme ends and the memeplex starts. What matters is that certain combinations of memes are very successful. Blackmore calls some synergetic combinations tricks. An example is the truth-trick. This refers to the phenomenon that memes that claim to be true spread better, even though they are not true per se. Other tricks that Blackmore mentions are altruism, social coercion, increase and then reduction of fear, and the illusion of control.

What Blackmore does not clearly bring forward, but Dawkins does, is that an important aspect of selection concerns memes that already dominate the meme-pool (Dawkins 1982a). In a society dominated by for example Marxist or Nazi memes, any new meme must be compatible with this background. If it is not, it could lead to the death of the individual, killing the meme in the process.

Vertical and horizontal transmission

An important difference between memes and genes is their way of replication. While genes reproduce only vertically (horizontal transmission due to viruses could be considered mutation), from parents to children, memes can also spread horizontally, for example from friend to friend or teacher to child. Vertical transmission of memes is especially important in earlier societies and helps to understand why some memes are (or at least have been) successful. Memes that increase birthrates increase their own spread via vertical transmission, as the children of those who have a certain meme also get the meme in their upbringing. An example is the taboo against homosexuality. As Blackmore explains: "Most homosexuals are at least partly bisexual and can, with strongly wielded taboos, be persuaded to marry and have children, to whom they will pass on the taboo" (Blackmore 1999, p135). Other examples in which the success of a meme can be understood from the perspective of vertical transmission are the religious promotion of large families and Catholicism's taboo against birth control. There are however also examples of memes that optimize spread of memes via horizontal transmission. Consider the idea of celibacy in Roman Catholicism. Priests are supposed to preach the Catholicism meme and even though they promote believers to breed as much as possible, they are themselves not allowed to have children. An interesting explanation was already given by Dawkins, namely that marriage, having children and raising them consumes a lot of time. Time that from the meme point of view could better be spent on spreading

Catholicism (Dawkins 1976). Here we see a case in which the memes of a host parasitize on its genes. Memes are selfish. Although Blackmore and Dawkins do not consider this, we should however keep another possibility in mind: if the priest succeeds in convincing his relatives to have many children, the end-result could still be in favor of the genes.

In modern times, society is of a much larger scale than the early small societies in which our brain and genes evolved. This means that the contribution of horizontal transmission is much larger than before, perhaps even larger than that of vertical transmission. Group effects of memes would have benefitted the genes in ancient times, because most people one would encounter were relatives. In a large society this is no longer the case. The modern society is therefore a breeding ground for memes that spread regardless of their benefits to a host's genes. Blackmore makes an interesting observation: "Rather surprisingly one of the consequences of memetic evolution is that humans can be *more* altruistic than their genes alone would dictate" (Blackmore 1999, p146). According to Blackmore memes for altruism, cooperation and generosity are more successful. She says: "if people are altruistic they become popular, because they are popular they are copied, and because they are copied their memes spread more widely than the memes of not-so-altruistic people, including the altruism memes themselves" (Blackmore 1999, p155). As the meme for altruism is successful, other memes can ride on its success. This is what Blackmore calls the altruism trick. Memes do not have to lead to altruistic behavior per se. In order to be more successful they just have to lead to behavior that seems more altruistic. Vegetarianism, for example, is helped by the fact that vegetarians seem nice, and since people want to be like nice people, vegetarians are more likely to be copied.

Alternative medicine

What I discussed so far provides a framework for memetic analysis. Let us look at how Blackmore uses this to assess alternative medicine. She defines alternative medicine as either treatments that are demonstrably useless or treatments that may be effective in appropriate circumstances but are claimed to work for the wrong reasons. This is an interesting topic, since alternative medicine is nonetheless successful as a meme. Why is this so? First there is a demand. Alternative medicine focuses on those people that are in fear of pain, disease or death. The fears need not even be realistic. The demand for relief of fear or pain is however not the main driver. The most important reason why people keep going to an alternative therapist is because they feel better afterwards; alternative medicine *seems* to work. This leads to the normative argument in favor of alternative medicine: if people feel better, what gives

others the right to judge against alternative medicine? It is clear Blackmore is strongly against alternative medicine, so let's focus on Blackmore's analysis of why people feel better. First there is cognitive dissonance. People pay for their therapies and what one pays for, one is more tempted to feel a benefit from. Next, there is the illusion of control. By undergoing alternative medicine people have the feeling that they are doing something about their health. This makes them feel good. Then there is social pressure. The therapist asks the patient nicely how he or she is feeling after the treatment. Since the therapist spent so much time and energy on the problem, and seems to be (and most often is) a nice person, patients feel obliged to acknowledge they feel better. Since our brains want to be consistent, saying one feels better, makes one feel better. The therapist can increase this by appearing as an authority with an insight in health or spirituality that the patient does not have. Explanations given by the therapist mix scientific sounding terms with deep spiritual insights, sometimes calling for unseen forces (e.g. chi, life-energy or any other form of invisible energy) or powerful beings (e.g. God or the devil). As these forces are supernatural, science cannot test them. Alternative medicine thereby in principle makes itself immune to scientific investigation. Finally, alternative therapists invoke the power of love, often they genuinely want to help and believe they are helping. Patients that feel obliged to tell therapists their therapy worked reinforce the beliefs of therapists in their healing powers. In the end, the memeplex of alternative medicine reinforces itself, and the fact there is money circulating in alternative medicine makes this reinforcement even stronger.

Religion

A similar analysis is given by Blackmore for religion. Note that her analysis comes from an atheist position, but that the problem at hand is not whether religion is true. Countless religious ideas are formed every day, yet there are but a few successful ones that survive and spread, e.g. Judaism, Christianity, Islam and Hinduism. What makes these religions so successful? First of all, they typically have a charismatic leader (e.g. Jesus, Mohammed) and make use of charismatic people to spread the word. Next there is the evocation and reduction of fear. The Christian God, for example, is all-knowing and ready to punish those who disobey the commandments. People are brought in a fearful state, and those who turn to Christ are offered forgiveness for their sins. God is said to bring love, but only to those who submit to the meme and put an effort in spreading it. Another reason why religions are so successful is that religion provides answers to questions that all humans have. Religions serve a real function. Even though religious answers may be false, humans sometimes tend to rather have a wrong answer than no answer at all. Religions utilize the truth trick, God is more or less

synonymous with Truth. The Word of the religion is the Truth. This Truth cannot be known directly, it requires faith. Not having faith is denying the truth and thereby God himself. Since God has punished for less, believers are afraid to even seek proof.

Religions also utilize psychological instincts. People turn to beauty. Successful religions use this for the beauty-trick. By putting resources in magnificent buildings and art, people associate the positive feelings with the religion itself, thereby contributing to the memes' successfulness. Religion also serves social needs of people, by giving them a sense of belonging. The altruism trick is very prominent in religion. Most believers are truly good people and they happily give resources (e.g. time, money) for the benefit of the poor. As people happily imitate the good, they are drawn towards the religion. Successful religions not only define altruistic and kind deeds as good, but include following religious commandments and obligations in what is defined as good. Helping spread the religion itself is considered to be a particularly good deed. Believers are convinced that everyone deserves to have "true knowledge".

Much of the money donated to religious institutions is however not used to help the poor, but to spread its memes. Even though the successful religions all claim to be peaceful, this generally only refers to the in-crowd of believers. Islam for example uses fatwas and jihads against nonbelievers, especially for those who renounce Islam itself. The ten commandments in Christianity deal for a large part with the obligation to believe in just the Christian God. Failure to comply results in punishment for not only the nonbelievers, but even their children for up to four generations (Exodus 20:2–17).

As discussed earlier, vertical transmission is important for religions. Most people have the religion of their parents. Since in modern times vertical transmission becomes less important, Blackmore expects religions to become less powerful as well. This is further driven by the fact that people no longer need to turn to religion for beauty. They can watch a movie or go to art galleries. The altruism trick also does not work as well anymore. Television shows them the horrible results of religious wars and abundant pedophilia. Blackmore ranks science as a memeplex higher than religion, since "Science is fundamentally a process; a set of methods for trying to distinguish true memes from false ones" (Blackmore 1999, p202). Unlike religion, which builds theories about the world and prevents them from being tested, science is all about testing the theories it formulates.

Problems of memetics

Although these analyses can have some appeal, they can also backlash onto memetics itself. Memetics has been accused of storytelling. Whatever goal one has, one could find a story supported by memetics, or so some critics say. In the two analyses one can also see that Blackmore uses all kinds of psychological mechanisms. Sadly she does not discuss what the position is of psychological mechanisms in the whole of memetics. The reputation of memetics as story-telling is strengthened due to its lack of empirical research, a requirement for a field to be a science. From 1997 to 2005 there was an online journal, the *Journal of Memetics – Evolutionary Models of Information Transmission*, but memetics did not succeed in developing to a mature science and the journal ceased to appear.

In her book, Blackmore discusses three other often-heard criticisms towards memetics. The first problem is: What exactly is the unit of a meme? Personally I would rephrase this as: what exactly is the unit that we call a meme? However, rather than answering the question, Blackmore tries to convince the reader that this question is not necessarily problematic for memetics. She compares this to the uncertainty about the definition of what exactly the gene is. Just as that did not impede progress in genetics and biology, uncertainty about the meme should not impede progress in memetics. She refers to a definition given by Dennett: "the smallest elements that replicate themselves with reliability and fecundity" (Dennett 1995, p344). What both authors refer to is similar to the definition of the gene by Dawkins as we saw earlier: "any portion of chromosomal material that potentially lasts for enough generations to serve as a unit of natural selection" (Dawkins 1976). Translated to memetics, this conceptual definition is good enough according to Blackmore. I believe however that Blackmore underestimates the importance of the success of genetics as a basis for people to accept the concept of the gene; memetics lacks this amount of success. If Blackmore believes the meme resides in the brain, then she should tap into neuroscience to increase acceptance of the concept of the meme.

The second problem Blackmore discusses is: What is the mechanism for copying and storing memes? Blackmore uses a similar strategy as with the first problem. Just as Darwin did not know about DNA, memeticists need not know the exact mechanisms of transmission. Blackmore speculates about the strength of synaptic connections in the brain for storing memes. This makes sense, though she does not work out how a meme could be instantiated in the brain. Blackmore makes an interesting observation that contrary to a computer memory,

the brain memorizes some information easier than others. What does this tell us about memetics? Sadly Blackmore does not give us an answer. Again, just as in the first example, what Blackmore does not mention is that Darwin's theory of evolution, contrary to memetics, has been confirmed by science over and over again.

The final problem Blackmore mentions is: is memetic evolution Lamarckian? This problem is tied to how variation is introduced and passed on. As discussed, Lamarckism is the inheritance of acquired characteristics. Lamarckism has a negative connotation, since in biology this is not what happens. In memetics the term is misplaced, as memetic transmission is fundamentally different from biological reproduction. For meme transmission Blackmore distinguishes between copy-the-instructions and copy-the-product. The first, she says, would be Darwinian, the second Lamarckian (since the causal arrow of inheritance moves through the phenotype). To learn how to make a soup for example, one could learn how to make the soup by copying the recipe, or one could reverse engineer how one could make the soup. Blackmore has no answer to the question which of the two processes (or both) drives memetic evolution. Whatever the answer is, Blackmore considers this problem a non-problem. This view is shared by Laland and Brown (2002), since memetic transmission does not lead to a change in our genes, which is what Lamarckism is about. I wonder however if Blackmore seriously considers this problem. The criticism points to the fact that cultural evolution seems to be a process that allows change in phenotype to be passed on. Without worrying about whether this deserves the label 'Lamarckism' or not, it does pose a problem for the gene-meme analogy.

Memetics, grounded in the analogy to genetics and the replicator idea of Dawkins, has been unable to mature into a scientific discipline. Whether it is the lack of empirical research, the refusal to respond seriously to criticisms, the preference for a political and popular discussion over a systematic and technical one, or a combination of these, the meme of memetics lacks what it takes to be successful. In the next section I discuss a field that does take the technical approach and focuses on the integration of culture and biology. This field is called gene-culture co-evolution.

2.2 Gene-culture co-evolution

In this second section I discuss gene-culture co-evolution, which is also known as dual-inheritance. Its name is derived from the ambition to investigate how the two independent evolutionary processes of cultural and biological evolution define us humans in a process that

is called co-evolution. As the basis for my discussion I use the theory described in the book *Not by Genes Alone: How Culture Transformed Human Evolution* (2004) written by two pioneers of this research field, Robert Boyd and Peter Richerson. Though gene-culture co-evolution is highly technical and explicitly mathematical, *Not by Genes Alone* does not contain a single mathematical formula. In my discussion of the field I adopt this approach by focusing on the philosophical implications of their work. The book focuses on the cultural rather than the genetic aspects of evolution, an approach that suits the aim of this work.

A large part of *Not by Genes Alone* aims to convince the reader that culture is an essential part of human evolution and crucial for understanding human behavior. Culture is part of our biology, yet its evolutionary behavior is distinctly different from that of genes. The definition of culture that Boyd and Richerson use is the following:

> "Culture is information capable of affecting individuals' behavior that they acquire from other members of their species through teaching, imitation, and other forms of social transmission. By information we mean any kind of mental state, conscious or not, that is acquired or modified by social learning and affects behavior. We will use everyday words like idea, knowledge, belief, value, skill and attitude to describe this information." (Boyd and Richerson 2004, p5)

Central in their work is population thinking. They view culture as something that is acquired, stored, and transmitted by a population of individuals. It is however the individual psychologies that "determine which ideas are likely to be easy to learn and remember and which kinds of people are likely to be imitated" (Boyd and Richerson 2004, p8). We for example evolved to rely mostly on imitation, not only on individual learning. What else evolved is that humans tend to conform to the behavior of the majority, imitate prestigious individuals and imitate people who are alike, even though this could result in maladaptive culture. It is however not our evolved psychology alone that determines cultural evolution, culture is itself subject to natural selection.

Culture, genetics and transmitted environment

Explanations of variation in human behavior can be grounded in three elements: genetics, culture and transmitted environment. Boyd and Richerson argue that the majority of variation can only be explained by culture. Genetics as the major contributor can be refuted by the fact that adoptees behave like members of their adopted culture and that behavior in populations changes faster than could be achieved by changing gene frequencies. The discussion of

transmitted environment receives less attention in *Not by Genes Alone*. It seems that we just have to accept the fact that its effects are small compared to culture. However, in a short intermezzo I would like to spend some words on it. The term transmitted environment is not commonly used. Rather, the term cultural niche construction is used to represent the change in our environment due to human behavior (Laland e.a. 2001). This change in environment modifies selection pressures (both genetic and cultural) within and across generations. The process is not unique to humans. Other animals change their environments as well, an example being the beaver constructing beaver dams. Culture, mainly in the form of innovation and technology, vastly expands human abilities to modify the environment. Laland e.a. (2001) state that cultural niche construction can influence evolution in a variety of ways, it could modify (both increase and decrease) natural selection pressures and lead to novel evolutionary outcomes.

Cumulative evolution

Humans are the only animals that show evidence of cumulative cultural evolution and it is only imitation that gives rise to it. How is culture good for us? The intuitive explanation would be that social learning allows most individuals to avoid the costs of individual learning. This can however not be the whole story according to Boyd and Richerson, since pure imitators are parasites who free ride on the learning of others. So we need an explanation that also explains why social learning improves the fitness of those who produce information. Boyd and Richerson present two factors that could contribute to this. First, imitation increases the individual learner's fitness as it allows for selective learning. It gives an organism the option to learn when learning is cheap and accurate and to imitate when learning is likely to be costly or inaccurate. A selective learner gains the advantages of both learning and imitation. The second way in which imitation could increase the individual learner's fitness is that imitation allows for accumulation of improvement. This is only possible in a population, not in a single individual. Although Boyd and Richerson do not mention this specifically, it seems that imitation is a mechanism that creates some sort of collective knowledge base for a population. Social learning is however expensive; it requires large brains that consume considerable amounts of energy. The costs only outweigh the benefits if the environment is subject to environmental change of an order and size that cannot be 'tracked' by hardwired genetic evolution. Based on models this situation requires rates of environmental change on the order of tens to hundreds of generations (Henrich and McElreath 2003). Possibly it is climate change of such an order that put a selection pressure on the development of our social learning capabilities (deMenocal 2011).

Cultural adaptations evolve by accumulation of small variations. According to Boyd and Richerson, contrary to the common belief that individuals are responsible for large changes in culture, no single innovator contributes more than a small portion of the total. Though human innovations are unlike random mutations, innovations have been small incremental steps. Boyd and Richerson argue that rational thought is only of limited influence in cultural evolution.

Cultural variants

From the definition of gene-culture co-evolution it follows that culture is information. According to Boyd and Richerson, the vast amount of information that exists in any culture must be encoded in some material object, the most important being our brain. This is so even in modern days where we have books, computers, artifacts etcetera. How the information is stored in our brain lacks scientific agreement. Boyd and Richerson use the term *cultural variant* for whatever is stored in the brain and could be referred to by the word idea, skill, belief, attitude or value. Note that the meme is also used to refer to the just-mentioned set of words. The meme however connotes "a discrete, faithfully transmitted gene-like entity" and according to Boyd and Richerson, cultural transmitted information is neither. The cultural variants are only "genelike to the extent that they carry the cultural information necessary to create cultural continuity" (Boyd and Richerson 2004, p81). Reproduction of culture takes place via a variety of processes of social learning, that includes, but is not limited to, imitation. Note that this is contrary to Blackmore who only considers imitation.

Boyd and Richerson warn us to take great care in analogies between genetics and cultural evolution. They say that at best cultural variants are only loosely analogous to genes. There are two reasons for this. First, cultural transmission does not have high-fidelity replication. Second, cultural variants are not always tiny snippets of information. What is similar however, is that both are fundamentally Darwinian in its basic structure. Analogies to biological evolution are productive since they provide us with a toolkit for building an evolutionary theory for culture. Another critique of co-evolutionary researchers on Dawkins' theory is that (discrete) replicators (with high copy fidelity) are sufficient, but not necessary for cumulative evolution (Henrich and McElreath 2003). Any process of cultural transmission that leads to accurate replication of the average characteristics of the population, for example replication at the population level, will work (Henrich, Boyd and Richerson 2008).

In line with Dan Sperber, Boyd and Richerson state that ideas are not transmitted intact from one brain to the other (Sperber 1996). What happens, they say, is that a cultural variant in one

brain generates some behavior that is observed by someone else in whose brain a new cultural variant that generates a more or less similar behavior is created. If you take this position, you have to conclude that the behavior itself is not the cultural variant. The behavior is some sort of phenotypic performance, while the cultural variant is more like a genotype. This also suggests that transmission goes via the phenotype, rather than via the cultural variant itself. We can thus wonder if it is the cultural variants that are copied. It seems that the behavior is what is copied and the cultural variants remain hidden for all transmission. This is problematic since what is modeled in the actual models of gene-culture co-evolution is the phenotypic performance. In the next chapter I come back to this.

Mechanisms of cultural evolution

In their model of cultural evolution, Boyd and Richerson distinguish between three groups of forces of evolution. The first group consists of the *random forces*: *cultural mutation* and *cultural drift.* Cultural mutation they say, holds all random individual-level processes, such as misremembering an item of culture. I wonder however if it is not better to consider the level of these processes at that of the cultural variant. It is after all the cultural variant that is changed, not the individual. Cultural drift is said to consist of effects caused by statistical anomalies in small populations. The second group of evolutionary forces are the *decision-making forces*, consisting of *guided variation* and *biased transmission*. Guided variation is the nonrandom change of cultural variants by individuals via some form of learning, the changed cultural variant is then further transmitted. Boyd and Richerson say that it has no good analog in biological evolution. Guided variation however looks like mutation, with the difference that guided variation tends to be fitness-enhancing rather than random. I think one could consider as guided variation the mental processes of creative thinking and the (rational) evaluation of the results of creative thinking (creative thinking thus creates imaginary cultural variants that can be evaluated). Biased transmission is itself split up in three biases. These biases represent differences in cultural transmission of cultural variants based on content (*content-bias*), commonness or rarity (*frequency-bias*), or observable attributes of the people that already exhibit the cultural variant (*model-bias*). The third cultural evolutionary force is *natural selection*, defined as the "changes in the cultural composition of a population caused by the effects of holding one cultural variant rather than others" (Boyd and Richerson 2004, p69). According to Boyd and Richerson this can occur at the level of the individual or the group.

The decision-making forces need not act on a conscious level. People are exposed to alternative cultural variants and make a conscious or unconscious choice among them.

Adoption of cultural variants is strongly affected by perceived utilitarian advantage. This requires comparison of the alternatives, which influences the rate of uptake. The harder it is to evaluate alternatives, the less likely it is that someone changes behavior. In some cases comparing requires some pre-knowledge or pre-existing world-view: "People who believe that disease is caused by magic may find it hard to believe that boiling drinking water is useful" (Boyd and Richerson 2004, p70). Furthermore, one can only compare cultural variants one is confronted with. When a new variant enters the population, initially its spread is slow, since there is not much opportunity to compare the new variant. If the new variant becomes more common the uptake speeds up due to a greater opportunity for comparison. According to Boyd and Richerson, at some point the old behavior is so rare, that there is less opportunity to compare, slowing down the rate of spread for the new behavior. The result is an S-shaped curve of the new variant rate of transmission. I think the S-shaped curve makes sense, but not for the reasons Boyd and Richerson give. If other people do something different from you, you can always compare your behavior with others. The status quo is always a position to compare against. The opportunity to compare your old behavior thus increases if the new behavior becomes more common. I think the S-curve is caused by the interaction structure between people and change aversion. Some people rarely come into contact with others. For them chances are lower they are confronted with and take up the new behavior. The same goes for the willingness to take up a new behavior. Some people do not want to change, but might be convinced by sheer numbers of other people that did change. This is driven by one of the heuristics Boyd and Richerson mention for taking up a cultural variant: "imitate the common type". This heuristic is part of the frequency-bias and could have evolved due to most successful behavior being adaptive, rather than maladaptive[8]. So, all other things being equal, imitating the common behavior is better than imitating at random. This tendency to imitate the common type is further supported by the existence of the conformist tendency. People have a strong urge to conform to the majority. The model-bias sets in when it is the characteristics of the people who already adopted a behavior that determine chances of adoption. This effect is strongest when the bearer of the cultural variants is successful or alike. In the first case this is called *prestige bias* and is built on the idea that if you imitate everything a successful person does, you ought to be successful too. An interesting thing is that this can lead to runaway processes. An indicator for success might become more

[8] Note that success of a cultural variant is determined by how many people adopted it, rather than how good it is for their genes. What is good for the genes is indicated by the term 'adaptive', while what is bad for the genes is indicated by the term 'maladaptive'.

important than the success itself. This can happen even when the indicator at first was mistakenly interpreted as an indicator of success.

Natural selection, the final force of evolution, acts on culture because culture satisfies three preconditions for evolution: people vary in which cultural variants they hold (variation), the variation affects behavior in ways that affect the spread of this behavior (differential transmission) and the total number of cultural variants in a population is limited (scarcity). Note that there is no specific mentioning of heritability. This is implicitly assumed in talking about cultural variants that spread in a population. The logic behind natural selection of culture is that cultural variants that cause people to behave in ways that make transmission of the cultural variants more likely increase in frequency. Boyd and Richerson correctly question themselves about why they distinguish between selection and biased transmission. They state that biased transmission represents why people preferentially adopt some cultural variants rather than others, while selection is about the likelihood that a bearer of cultural variants is imitated, because these variants affect the life of the bearer in certain ways. In case of the prestige-bias this leads to something strange. If a behavior leads to success, it is copied and deserves the label natural selection. While if the behavior is mistakenly assumed to determine success, it is labeled biased transmission. This supports my intuition that the classification of evolutionary forces given by Boyd and Richerson is open to improvement.

Just as in memetics we can conclude that it is the cultural environment, the evolved psychology of the individual and the content of the cultural variant itself that determines the success of a cultural variant.

Competition

How do cultural variants compete? According to Boyd and Richerson, the either/or dichotomy that we saw in competition between the alleles of a gene may not be appropriate for culture. People can learn and remember more than one variant. They state that cultural variants compete in two ways. First, cultural variants compete for cognitive resources of the learner, both during the process of learning and in the maintaining of the variant in memory. One can for example not study law, French and history of arts at the same time and expect to be an expert in all three. This effect is more important if knowledge is harder to acquire. More complex knowledge requires more resources and therefore suffers more competition from other cultural variants. The second way in which cultural variants compete is the control of behavior. Behavior that does not get expressed is not transmitted, unlike in genetics, where recessive or silent genes can still be passed on.

Accumulated culture can become so extensive that a single individual cannot learn all culture in his or her population. That means that a complex culture requires multiple brains to be maintained. A complex culture thus requires a large enough population to sustain the culture over generations. In small populations complex behavior could deteriorate due to the effects of for example cultural drift. This is what happened in Tasmania, when a small part of a population became isolated from the rest, resulting in a loss in tool complexity in the isolated group. This technological loss among partially isolated cultural groups is thought to be more common than is recognized. Joseph Henrich created a mathematical model that helps us understand and predict what happens with respect to cultural complexity under varying population size (Henrich 2004).

Maladaptive culture

It is culture that rules most of our behavior, not biology. One of the arguments Boyd and Richerson use for this is that if biology would rule, we would use our wealth to increase the number of children we get. Rather, the opposite happens. Boyd and Richerson blame the prestige-bias: in modern societies people focus on professional achievement and expensive toys and hobbies. Cultural traits like these that lower biological reproductive success are called maladaptive. Boyd and Richerson hypothesize that maladaptive cultural variants can spread because it is (practically) not possible to evaluate all cultural variants one encounters; evaluation is costly. To understand why maladaptive cultural variants spread one can use an analogy with memes. They state: "you can often understand what kinds of cultural variants spread by thinking of them as selfish memes, even if the analogy is weak in other respects" (Boyd and Richerson 2004, p153).

So why did biology not filter out the possibility for maladaptive culture? This is because selection cannot get rid of cultural maladaptation without giving up the positive effects of culture in dealing with changing environments. If we would evaluate all cultural variants so thoroughly that no maladaptive variants are imitated, the costs of social learning would be simply too high to make it worth it, that is assuming that we are theoretically able to evaluate the effects of cultural variants. If the latter is not the case, the only way to protect ourselves from maladaptive culture is to drop social learning entirely, along with its adaptive effects. So the imitation heuristics of our evolved psychology on average benefit our genes, but open the possibility for maladaptive cultural variants.

Co-evolution

As the name suggests, gene-culture co-evolution combines cultural evolution and biological evolution. Boyd and Richerson built a convincing case of why culture is important in the study of human behavior, but they do not stop there. Also for biological evolution, culture is important since cultural variants can affect the fitness of genotypes. A classic example of gene-culture co-evolution is the relation between lactose tolerance and dairy farming. Most of the world's adult population gets ill if they consume dairy products, due to lactose intolerance. This raises the question how in some societies the majority of adults actually can drink milk. Researchers were able to use gene-culture co-evolutionary models to describe the spread of both lactose tolerance and milk digestion. They showed that dairy farming can create the selection pressures that lead to the spread of the allele for lactose tolerance (Feldman and Cavalli-Sforza 1989). This is however just one of the examples. According to Boyd and Richerson co-evolution also played an important role in the evolution of human social instincts and human social institutions - a view that is shared by others (e.g. Deacon 1997).

Criticism

As I mentioned at the beginning of this section, the field of gene-culture co-evolution is highly mathematical in nature. These mathematical methodologies "allow gene-culture coevolutionary researchers to derive a system of equations that describes how the relevant gene and meme frequencies change over time in the face of cultural selection, natural selection, and various kinds of interactions and biases" (Laland and Brown 2002, p258). More so than memetics, researchers in this field seek to link theorizing about human nature with empirical data. Compared to other established sciences, gene-culture co-evolution is less empirically oriented. It started as, and still is, mostly a theoretical field. The fact that it is technical could, according to Laland and Brown, be a reason for the field not receiving so much criticism as memetics. The objections that were nonetheless raised along with the response by Laland and Brown (2002) are the following:

1. It is doubtful that culture can be modeled in terms of discrete psychological and behavioral characteristics.

To this first criticism Laland and Brown respond in a similar way as Blackmore did with the problem of the definition of the meme. Assuming that genes are discrete, even though it may be somewhat problematic to define what exactly a gene is, brought the science of genetics forward. A similar approach in cultural evolution is therefore justified. Laland and Brown however also respond to the content of the problem. If the brain is where culture resides, and

the brain works by storing culture as discrete units and knowledge structures, then it is not an extraordinary claim that culture is acquired in bits and pieces.

2. What is the legitimacy of the use of population genetics to model culture?

To this second problem they respond in a pragmatic way. They state: "Ultimately what matters is whether the models that have been constructed are good models in the sense that they capture the essential properties of the system" (Laland and Brown 2002, p276). That aside, they state that most of the skepticism aims at the question whether cultural evolution can be separated from biological evolution. Laland and Brown refer, just as Boyd and Richerson extensively do, to analyses in which gene-culture models perform much better than single process models. Scientific success is thus the ultimate judge for legitimacy.

3. It is doubtful that fast changing culture and slow changing genetics truly can co-evolutionary interact.

According to Laland and Brown cultural change can be slow as well (e.g. hominid stone tool technology), while biological change can be fast (e.g. in artificial selection). This objection is thus not a valid argument against co-evolutionary theory. Laland and Brown think that the past two million years of human evolution were in fact dominated by co-evolution. They support their confidence in the existence of co-evolution by a reference to a book by William Durham in which he describes five categories of gene-culture interaction supported by empirical data (Durham 1991).

4. Gene-culture co-evolution lacks an empirical basis.

This final criticism has still to be tackled by the researchers, by going out and finding problems to which they can apply their models. A nice example of such an effort is the Tasmania case of tool complexity reduction due to decreased population size that I mentioned earlier (Henrich 2004).

2.3 Comparison

Memetics and gene-culture co-evolution both target the evolution of culture. The fields are in many aspects similar, though differences can be distinguished. In this section I discuss both the similarities and the differences, drawing from the previous sections, as well as from an in-depth comparison by Laland and Brown in their book *Sense and Nonsense* (2002).

Level of explanation

The first difference is the level of explanation. Memeticists seek to explain human variation solely from the perspective of memes; culture has become so determining that biological evolution is considered to be of minimal importance. Gene-culture co-evolution, as the name suggests, specifically brings together the separate processes of cultural evolution and biological evolution together. This might not be so clear from this chapter due to my focus on the cultural aspects of the field, but the level of explanation for gene-culture co-evolution is both that of the cultural variants and that of the genes.

Unit of selection

The unit of culture of both fields seems similar at first. Both cultural variants and memes point to the same set of words (beliefs, ideas, etcetera). Laland and Brown do not even mention the term cultural variant. For them gene-culture co-evolution is the combination of memes and genes. It is thus not surprising that both fields face the same problem: the status of the unit of culture. The difference between cultural variants and memes is however that memes are considered to be discrete entities, while cultural variants need not necessarily be discrete. Cultural variants do not even have to be replicators. A similarity between cultural variants and memes is that both can be maladaptive.

Methodology

A major difference between the fields is the methodology. Memetics uses meme's-eye-view reasoning to explain and predict why certain memes are successful. Gene-culture co-evolution uses mathematical models. Ideally these approaches lead to the same results, though using models is less prone, but certainly not immune, to the accusation of storytelling. This difference in the potential of drawing negative publicity also comes from the examples that are used. Memeticists apply their ideas to 'sensitive' topics such as religion, while the examples of gene-culture co-evolution seem more 'innocent'. The methodology of memetics can be easily applied in debates about culture, which memeticists eagerly do. Combined with the difference in level of explanation, this brings forward another difference, namely that memetics seeks to explain relatively short-term contemporary processes (from within one generation up to 3000 years), while gene-culture co-evolution seeks to explain long-term evolutionary change (from multiple generations up to two million years).

Mechanisms of transmission

The processes of transmission are similar, though more worked out in gene-culture co-evolution. Gene-culture co-evolution is for example more clear about its use of psychological

heuristics. Another difference is that memetics does not leave room for rational thought. Human beings are just animals that are manipulated by cultural parasites. If humans are rational at all, it is some meme (for example the science meme) that makes them rational. Gene-culture co-evolution is also less open to rationality than for example the philosophies of enlightenment thinkers, but it introduces rational behavior in the form of evolved heuristics, assessment of alternatives and creative thinking.

Group selection

The final important difference is that while in memetics all that matters is the meme, gene-culture co-evolution, especially the work of Boyd and Richerson, leaves open the possibility of group selection. For Dawkins, however, a group can be a vehicle and thus function as a proximate target of selection, but a group is not a replicator. If the behavior or characteristics of a group change, it can only be explained by the change in behavior of individuals, and thus by the change in memes or cultural variants. Perhaps what Boyd and Richerson mean, without making this explicit, is that a group can be a proximate target of selection even though it is not a replicator. An argument for the population approach of gene-culture co-evolution is that culture is usually stored distributed in a population. A single individual cannot be the carrier of a complex culture. I expect that this population view is important to explain complex social phenomena.

In this chapter I analyzed two theories of cultural evolution. In the next chapter I use these theories as well as philosophical elements from biological evolution to come to a metaphysics of cultural evolution. In the process I provide additional reflection on both memetics and gene-culture co-evolution.

Chapter 3: Metaphysics of cultural evolution

In this chapter I formulate the metaphysics of cultural evolution. This metaphysics can function as the foundation for cultural evolutionary thinking. In this chapter I take four steps. In the first step I derive an ontology for cultural evolution that conceptually separates culture as phenotype from that which carries the essence of culture as genotype. I define the meme as an element of genotype, being a replicator that makes cultural evolution possible. In the second step I look for the material instantiation of the meme. I argue that memes are pathways in the brain. From this position I work out how we may understand the mechanisms of cultural transmission. The third step is to assess how evolutionary forces act on memes (and their cultural products) and how central dogmas of memetics and gene-culture co-evolution fit in this framework. In the last step I reflect on the potentially disturbing implications of this metaphysics, namely that it implies we have no free will and are slaves to memes that are bad for us.

3.1 A unit of culture?

In the previous chapter I discussed two theories of cultural evolution and although I presented a definition of culture by Boyd and Richerson (2004)[9], the definition of culture itself was not the central theme. Before I look into the question whether there is a unit of culture and what such a unit of culture might be, I contemplate about what culture is.

What is culture?

Culture has many definitions, but two important uses of the word are:

1. An integrated pattern of human knowledge, belief, and behavior that depends upon the capacity for symbolic thought and social learning.
2. The set of shared attitudes, values, goals, and practices that characterizes an institution, organization or group. [10]

The first definition is similar to the definition given by Boyd and Richerson. It reflects an individualistic concept of culture in the form of characteristics that can be ascribed to an

[9] "Culture is information capable of affecting individuals' behavior that they acquire from other members of their species through teaching, imitation, and other forms of social transmission. By information we mean any kind of mental state, conscious or not, that is acquired or modified by social learning and affects behavior. We will use everyday words like idea, knowledge, belief, value, skill and attitude to describe this information." (Boyd and Richerson 2004, p5)

[10] See also: http://en.wikipedia.org/wiki/Culture

individual. It also distinguishes culture from genetics, the other determinant of behavior. The definition does however not see culture merely as a determinant for behavior, like Boyd and Richerson do in theirs; it includes the behavior itself.

The second definition points towards what we typically refer to when we talk about *a* culture. It reflects the concept of culture that 'transcends' the individual. It reverses the relation between the individual and culture. It is not culture that belongs to the individual, but the individual that belongs to a culture. In this second definition of culture, the group seems to have precedence over the individual. This idea is made more clear by an alternative for this definition:

- Culture is a system for differentiating between in-group and out-group people. [11]

Both the individual and the group definitions of culture refer to social interaction. This definition suggests there can be no private culture, just as Wittgenstein (1953) argued that there can be no private language. We encountered this social element before. In Boyd and Richerson's (2004) definition of culture, but also in Blackmore's definition of the meme (1999), culture is only culture after social transmission has occurred. Strictly interpreted this however excludes a behavioral precursor that originated in the individual itself, but nevertheless can be transferred; a new cultural variant is not considered culture for the person that started a new behavior. I therefore think culture should refer to what can be *potentially* socially transmitted; we should not have to wait for a new precursor to behavior to be transmitted before we can call it culture. In analogy to genetics: a mutated gene is still a gene, even though it has never been copied. It is therefore meaningful to speak about culture even on the level of the individual.

In this perspective on culture, culture and also *a* culture can exist for a group consisting of just one individual. The first definition of culture, as characteristics that can be ascribed to an individual is therefore primordial; only after one can explain what culture is for an individual can one use it to classify groups. The object of the second definition emerges from individual culture. This object, *a* culture, refers to a state of equilibrium in which one or more cultural variants have a stable and dominant position in a group or population[12].

[11] http://changingminds.org/explanations/culture/what_is_culture.htm
[12] One can study the dynamics of cultural equilibria using game theory, see for example Skyrms (2004).

The discussion of culture on group level versus culture on individual level is very interesting and important for sociology. It is also important for the study of cultural evolution as a historical process. This shows that culture works at many levels. Given my restrictions in time I choose not to analyze the mechanisms of group-level phenomena. I realize that I do not give the perspective of group-level evolution as much attention as the perspective deserves (and as I would like). I do for example not discuss the implications of the fact that *a* culture can be so complex, that it requires a certain population size to be maintained (e.g. Henrich 2004). I however strongly believe that group-level processes are ultimately determined by lower-level processes. To understand group-level processes it is necessary to understand the processes at the level of the individual.

The second definition for culture is open to another interpretation, namely that culture is an independent object. With this I mean that *a* culture can be thought as causal for certain phenomena. We are for example born in a specific culture; how we behave can be ascribed to this culture. Our behavior can thus be understood as originated in the institutions that we live in. We encountered this position before when I shortly mentioned cultural niche construction. It refers to alteration of our (cultural) environment that affects not only us, but also future generations. The question is however if *a* culture or a cultural niche really has causal agency on the level of the individual or whether this is merely an efficient way of thinking about culture. In the case that the cultural niche is thought of as, for example, a dominant culture in a population I believe the answer points to the second view. This view is however not sensible when we consider a cultural niche to be a cumulatively changing physical environment that exerts a selective pressure on our culture. On the other hand, although our options for behavior are driven by our physical environment, there is variation in which of the options people choose. What is the target of this metaphysics is not the change of the environment, but the predisposition of people to choose one behavior over the other.

To summarize I argue that ultimately it is the processes at the level of the individual that determine cultural expression of groups of people, even though the behavioral repertoire can be fixed by the physical environment. In the rest of the chapter my focus is therefore on culture at the level of the individual.

Cultural phenotype and genotype

Let us now investigate this primordial concept of culture. Both gene-culture co-evolution and memetics are ambiguous about whether culture is genotypic or phenotypic. Boyd and Richerson reject a genotype-phenotype account of culture, but in their definition of culture

they refer to culture as information capable of affecting behavior (2004, p5), suggesting that culture is genotypic, while in their examples they refer to culture as something that is observable, which suggests it is phenotypic. Dawkins (1976, p192) proposes memes are ideas or tunes, while later he adopts the information-in-the-brain definition (Dawkins 1982a, p109). Blackmore combines both views as well: a meme is the instruction for behavior stored in a brain (Blackmore 1999, p43), but a meme can also be the first four notes of Beethoven's *Fifth Symphony* (Blackmore 1999, p53). Can a cultural variant or meme be both genotypic and phenotypic? Is this a sensible dichotomy for culture?

The origin of our concept of culture lies in similarities in observed behavior and its products, for example in art or architecture. These similarities and our personal experience tell us that culture can be copied. What it is that is copied is one of the major questions; it is determining for how culture should be defined. Let us take a look at the copying process. Laland and Brown distinguish between three means of meme acquisition: "copy-the-process (that is, reproduce the behavior), copy-the-product (reverse-engineer informational content of the meme) and copy-the-instructions (exploit a syntactic depiction of the meme)" (2002, p 221). In an example they use as a meme the knowledge how to make a soup. What they could mean by knowledge requires closer analysis. If the means given above are three distinct ways to acquire a meme, then none of these intermediaries (behavior, information and depiction) can be the meme itself. Knowledge can therefore not mean information; a book can contain the recipe for a soup and thereby the knowledge for the soup, but the book cannot make the soup. When we also consider that the product (e.g. a soup) is not a meme, we refuted everything that we typically consider to be culture in its original meaning. This is an important result. It tells us that culture, as we normally use the word, is not genotypic, but phenotypic. The meme then would be the precursor for culture, not culture itself. In analogy with genetics: the gene for blue eyes is not a blue eye, but is nevertheless required for blue eyes. This leads us to an even more fundamental result, even if we chop up culture in tiny bits, this does not give us the meme. We have to conclude that in our discussion of cultural evolution we must make a distinction analogous to biological evolution between genotype and phenotype, where genotype is necessary (though not sufficient) for phenotypic expression.

In this distinction, the concept of culture refers to phenotype, while the concept of the meme refers to (an element of) genotype. In much of memetics this approach is however not taken; most authors take the meme to be both the catch phrase or tune and that which causes a person to speak out the phrase or whistle the tune. Dictionaries even use as the definition of

the meme: the unit of cultural information[13,14]. This is however not what I take to be a meme, since in the dictionary definition it lacks something: material instantiation. Just as a gene only has causal power due to its material instantiation, a meme as merely information cannot cause anything; the symbolic sequence of a gene could not make you a protein, only the molecular sequence could. In a sense one can say that I sharpen Dawkins' concept of the meme; as a (physical) replicator that is genotypic.

If we generally use culture for phenotypic expression, then it is fair to assume that a unit of culture is generally understood as a unit of phenotype. Is such a unit of culture also the unit of cultural evolution? Our discussion of evolution in biology showed us that these two were not necessarily the same: the species may be considered to be the unit of phenotype, but it is the gene that is the unit of evolution. By analogy, we could state that the meme is the unit of cultural evolution, though it is not the unit of culture itself. However, we can only believe in this conclusion if we have enough reasons to believe in the analogy itself, and exactly the analogy is problematic. There is an important difference between genetic and cultural evolution. This is that in cultural evolution transmission takes place through the phenotype; transmission requires phenotypic expression of culture. In the case of imitation this is obvious; you can only imitate someone if you first observe the person. The question whether a unit of culture is also the unit of cultural evolution thus remains open. Before we proceed with this question let us first consider the field of gene-culture co-evolution once more.

Gene-culture co-evolution

We can ask the question whether the result of a meme being a unit of genotype, rather than a unit of culture, also applies to cultural variants? To answer this we have to remember that gene-culture co-evolution does not see as strict an analogy between cultural evolution and biological evolution as memetics; in fact it warns us, as we saw with good reasons, not to overvalue this analogy. The goals of the field are however different from those in this work, they are more scientific. If a gene-culture co-evolutionary model succeeds in explaining and predicting social phenomena, the model is good. This criterion is not sufficient for a philosophical perspective on cultural evolution. In this philosophical project I seek to describe a metaphysics of cultural evolution that aims to be both philosophically consistent and help us understand reality. What is missing in gene-culture co-evolution is the distinction between cultural genotype and phenotype.

[13] http://www.dict.cc/?s=meme
[14] http://en.wikipedia.org/wiki/Meme

Cultural variants can be continuous, as opposed to memes that can merely be discrete. Boyd and Richerson (2004) argue that cultural variants do not have to be discrete to give rise to cumulative evolution, but at the same time they do not explain why they may be continuous. I think the correct explanation for this is that what gene-culture co-evolutionary scientists model are not the units of cultural evolution, but the units of culture; they model phenotype. Is this wrong? Not at all. For scientific purposes that seek to explain observed phenomena it makes sense to set up a model in terms of those phenomena. It makes sense to see culture as continuous, because of what is called phenotypic plasticity. This is caused by variation in development, leading to variation in phenotype. Cloned crop for example, where each plant has identical genotype, when sown in a field does not lead to plants of identical length; genotype is not the whole story of biology.

The crop example also shows the restrictions this approach could have. In the case of cloned crop, genotype is necessary to explain inheritance of traits; offspring of the smaller corn at the boundaries of the field is exactly as fit as offspring of the larger corn in the center. The question is thus whether a purely phenotypic approach of culture ignores similar effects, taking in account the difference that cultural transmission proceeds through phenotype. What we need to know then is if there are processes occurring at the level of the genotype that are invisible to phenotypic enquiry. One contender could be phenotypic availability. Recall that Dennett explained that not all phenotypes are biologically possible; parts of Design Space are inaccessible due to the laws of our universe. Biological evolution therefore happens in jumps; there are no intermediary phenotypes. Something like this could be the case in cultural evolution. This is not taken into account when one models cultural evolution with continuous phenotypic units. A similar problem occurs when Boyd and Richerson dismiss individual contributions as determining cultural history. Biological evolution utilizes cranes (as Dennett calls them), sudden openings of a whole new area of Design Space. I think it is reasonable to believe similar events occur in cultural evolution. When some innovations are not made available, a part of Design Space remains hidden. Without a person making such a contribution, society as a whole would not be able to step up to the next level. Even if cultural evolution largely occurs as a bits-and-pieces process, it does have its sudden jumps; individuals might be more important than Boyd and Richerson claim, and hence piecewise change in phenotype may not give a complete picture. In defense of Boyd and Richerson I do think that most innovations do not depend on specific individuals. This is due to forced moves, steps in Design Space that are taken over and over again, possibly because there is no other way to do it. In biology we ascribe this phenomenon to the laws of the universe

(remember the example of bird and bat wings); for culture we must include biological laws as well.

Upon closer analysis, gene-culture co-evolution is not the study of the change in cultural variants; it studies the change in frequency of variants. Its central paradigm is population thinking, the study of the dynamics of existing cultural variants in a population. It is the cultural analogue of population genetics, which studies the change in distribution of alleles in a population. Both fields can introduce mutants in a population, but these mutants are introduced in a state where the mutant variant or gene is initially rare; the process of mutation itself is not modeled. In the vast majority of cases this approach is sufficient for scientific questions. The project of including mutation would at this point be unrealistic. In analogy: to understand the effects of a random point mutation in our DNA, we need to have a full understanding of biochemistry, development and environmental effects. As to which phenotypes are possible, we are therefore limited to what is provided by nature (and similarly culture). Gene-culture co-evolution is, as every science, limited to a certain set of phenomena; their scope is smaller than the whole of cultural evolution. A metaphysics of cultural evolution can therefore not be based on gene-culture co-evolution alone.

Intermezzo

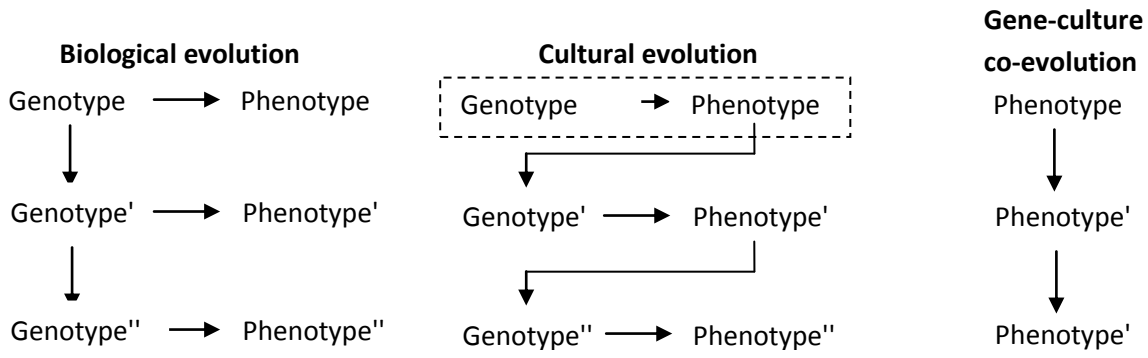
Let us shortly summarize what we achieved so far. I started with the distinction between the individual definition of culture and the group definition of culture. I argued that the first is primordial and therefore the focus of this work. From the analysis of the nature of the meme I concluded that what we typically understand as culture is phenotypic. A unit of culture is therefore not necessarily the unit of cultural evolution. Even though memetics uses the meme for both, I argued that the meme should only be used for genotype. With this distinction between cultural genotype and phenotype I was able to give an analysis of gene-culture co-evolution as a discipline that utilizes the phenotypic concept. I concluded that a metaphysics of cultural evolution can therefore not be based on gene-culture co-evolution alone.

Let me first respond to a potential objection towards the postulating of a genotypic analogue in culture. My argument so far has been the following. Culture brings together many non-identical concepts like behavior, information, art(ifacts), expressed beliefs and representations. As a philosopher I would like to unify these concepts. Since behavior is fundamentally different from something like a painting, the unification cannot occur at this level. The unification should therefore take place at a different level, which I propose is the

cause for this manifold of concepts. This cause is genotypic, while the concepts are the expressed forms of culture.

I could now object as follows: "Okay, in biology I can see that we have something like DNA which is our genotype, but culture is different. Your claim is not legitimate and seems to come from a too strict analogy with biology." This is a plausible objection, but as we will see it does not count as a refutation of cultural genotype. How do we know that we need something like genotype in biology? This is because traits are not constantly expressed. A butterfly pattern is for example not expressed in the caterpillar (the butterfly larva). When the time comes the phenotype is expressed, there has to be something which holds the essence of what it is that is expressed. We see something similar in culture. The way I put my signature on a form is only expressed when there is a need to do so; nevertheless it is the same every time I sign a document. There thus needs to be something that holds the essence of my signature that is causal to the way I sign. This something is the cultural genotype.

Using the diagram below I summarize how biological evolution, memetics, gene-culture co-evolution and the metaphysics I propose interrelate when it comes to genotype and phenotype. Biological evolution has genotype to genotype transmission, without phenotype-to-genotype inheritance. As I discussed cultural transmission occurs via phenotype, where I define the meme as referring to an element of genotype. Blackmore and Dawkins use a concept of the meme that is both genotypic and phenotypic; this is indicated by the dashed box. Gene-culture co-evolution models phenotype-to-phenotype transmission, even though its definition of culture suggests a genotypic account of culture.



Replicators

The question that remains unanswered is whether the (phenotypic) unit of culture is also the unit of cultural evolution, or whether only the (genotypic) meme can be referred to in that

way. The concept of the meme as the unit of cultural evolution corresponds to the original idea that Dawkins had when he wondered if there are other replicators than genes. This started as a thin but nevertheless interesting philosophical idea. The meme the way I defined it as a genotypic (physical) replicator is a sharpening of this idea. It is sharper in two ways. First, in his original definition Dawkins uses the meme for phenotypic expressions of culture as well. Second, in a later definition Dawkins uses the information view on the meme, which lacks material instantiation.

For Dawkins, replicators are entities of which copies are made (1982a, p83). He distinguishes these from vehicles, the units that work as a unit for the preservation and propagation of replicators (1982a, p113). It is the vehicles that express phenotype, and it is in the vehicles that replicators are preserved and copied. The most obvious vehicle for memes is the individual, but even the brain, a part of the brain, a group of people or a whole nation can be considered a vehicle. The metaphysically most important vehicle is the individual, since it is the smallest type of vehicle that is self-preserving. The brain cannot exist without the rest of the body, while a nation is just a collection of individuals. When I use the term vehicle from here on, I thus mean individual human organism. Were we however to consider the unit of culture as a replicator as well, then we could even consider a word as the replicator and a book as its vehicle. A book is however not a self-preserving unit and it cannot pass its content to another book; if you put two books in a room, without any human intervention there will be no transfer of content. We could however still defend the position; just like we can consider that sheep are using us for their breeding, we could consider that books use us to get them copied. Even more difficult is it to make a distinction when we consider computer viruses. They do replicate themselves. We should however focus on culture in its original meaning, as the integrated pattern of *human* knowledge, belief, and behavior.

In what way then should we think about replicators? We are interested in cultural evolution. Since this is a historical process, we are interested in that what *is*, *was* or *will be*, we are interested in *being*. This means we are interested in the *being* of replicators. When we talk about the success of a replicator, we mean that it succeeds in *being*. How do we then compare two replicators; which is more successful? Is it the one that has most copies, is it the one that *is* for the longest period of time, is it the one that is expressed most (synchronous or asynchronous) or is it measured by some entirely different standard? This shows that success is a normative perspective and relative to the question we ask. What we are looking for in a metaphysics of cultural evolution is a system that can answer all of these questions.

Description, prediction and explanation of specific historical states of culture are not the goal of this project; these are scientific aims. What I am looking for are the pre-conditions for cultural evolution to occur.

There is one question that for some time confused me. Why do we need replicators to preserve *a way of being*, our essence[15]? Can't there be something outside of us that remains the same, something that we just tap into? I could for example come up with the (religious) idea that there is a God that with every starting of life injects the new organism with its essence. The discovery of genes and DNA showed us that such a view is not required, the essence of an organism can be acquired from other life. But why did we in the first place need a God to preserve our essence? The answer is death, the end of *being*. Nothing material in the universe is eternal. When *being* ends, essence, *the way of being*, is lost. It is for that reason that we need replicators. If there were no (cultural) replicators, essence would die with its vehicle and culture would not be possible.

It is however still not clear what is the 'true' unit of evolution, the meme or some cultural phenotypic unit (that we could think of as Hull's interactor, a cultural variant or a replicator in itself). Contrary to phenotype in biological evolution, cultural phenotype has a causal arrow towards the meme. This makes phenotype more important (as a unit of evolution) in cultural evolution than in biological evolution. We can however distinguish between dead and living culture, where the living culture is what living people express. It is living culture that is under investigation when we talk about cultural evolution and since living culture is ultimately determined by what memes drive the behavior of people, it is the meme that I consider to be the fundamental unit of cultural evolution; it is the meme that by its replication carries the essence of living culture through time.

3.2 What is a meme?

One of the criticisms towards memetics was that it cannot tell us what a meme is. In the last section I sharpened the concept of the meme; the meme is that which by its replication carries the essence of our non-genetic behavior through time. When people usually ask the question what the meme is, such a conceptual idea is often not enough. What they mean is: show me where I can find the meme. This makes sense; if we claim that memes define part of our

[15] Essence can be defined as the attribute or set of attributes that make an object or substance what it fundamentally is, and which it has by necessity, and without it loses its identity (Source Wikipedia).

reality, we have to be able to point them out. The obvious place to start the search for the meme is in the brain, the place where Boyd and Richerson (2004) state culture resides. In their work the brain is however largely ignored. This can be explained from the result we got earlier, that culture is phenotypic and that gene-culture co-evolution studies culture as phenotype. I therefore think that their definition of culture, which seems to point to genotype, is not consistent with the rest of their work. That aside we concluded that in this work we are interested in the unit of cultural evolution, the meme. This requires 'genotypic' analysis. In this section I try to merge my knowledge on neuroscience with what we discussed so far in order to come to a physical answer to the question "what is a meme?".

The brain

Our brains work in peculiar ways. There are 100 billion neurons, each with many connections, sometimes up to thousands, yet there are only about 30.000 genes. How is this possible? Though our general brain structure is coded in our DNA, most of its details are not. It turns out that the complex structure of our brain is formed by a Darwinian process. After birth we do not gain connections, we lose them. Connections (and neurons) we do not use are destroyed. What remains is a structure that is optimized for what it does, with connection strength correlated with use of the connection. This process is driven by Hebb's law[16] (Hebb 1949). One can understand this process with the metaphor of a walking path through a patch of grass. If a lot of people walk on it, the grass is damaged and the path is reinforced. If few people walk the path, the grass can grow and the path becomes smaller. If no people walk the path, the path eventually disappears.

This metaphor is useful for another reason. Neurons can activate each other via their connections; activity therefore seems to travel through the brain. These patterns of activity define the active state of the brain. The state of this 'walking path' of activity, the neural pathway, is the object of my analysis. So rather than talking about connections and neurons I would like to talk about patterns, pathways of activity in the brain. This term I borrow from Jeff Hawkins and Sandra Blakeslee, who in their book *On Intelligence* (2004) explain how the brain is a general computing device that uses patterns to make predictions. What I mean with pattern here is however not an algorithm that finds its instantiation in the brain; in the concept of pattern I include the physical instantiation of the pattern. The concept of pattern includes

[16] Hebb's law states that: "When an axon of cell A is near enough to excite cell B and repeatedly or persistently takes part in firing it, some growth process or metabolic change takes place in one or both cells such that A's efficiency, as one of the cells firing B, is increased." (Hebb 1949, p62)

both its activated and its non-activated state. Pattern thus refers to the neural pathway itself. Pattern is however distinct from a particular neural pathway in the brain of a particular individual; pattern refers to a neural pathway that can be in anyone's brain, where every instantiation of the pattern in someone's brain is identical in its essence, but not necessarily in its neural environment.

In the previous section I derived that the meme is the unit of cultural evolution, an entity that by its transmission preserves the essence of cultural expression through time; though its vehicles (individual human beings) die, as a replicator, the meme transcends the life of its vehicle through replication. Could replication be possible through the brain's Darwinian self-organizing process?

Phenotype-to-genotype transmission

Let us compare humans to other animals. Humans have much more capabilities for social learning, especially for imitation. Where does this difference come from? Animals have central nervous systems, so it is to be expected that the (detailed) structure of their brains is the result of the same Darwinian pruning process that defines human neural connectivity. The Darwinian process of neural connection formation itself can therefore not be enough to explain culture. According to Terrence Deacon (1997) our unique cultural capabilities arise from our capacity for symbolic learning and thought. We can abstract from content. This also happens for actorship. If we see another person do something, our brains process this information in a symbolic way; in our perception we already understand that it might as well have been us who was the actor. This way of viewing our perception makes sense when one considers mirror neurons. These neurons have been shown to become active whenever any actor, the person itself or someone he sees, performs a specific action. It has even been claimed that it is the mirror neurons themselves that explain culture, the great leap forward in human evolution (Ramachandran 2006). The existence of mirror neurons in other animals tell us this cannot be the whole story though.

I doubt that we actually need to have a conscious concept of an actor, as long as actions are recognized as potential actions that one can perform oneself. I also believe there does not need to be conscious thought to recognize an action. This perspective on perception is similar to the one that was propagated by James Jerome Gibson (1979), who argued that what we perceive are possibilities for action. Perception gives us immediate information about our action space. A theory of direct perception makes sense in light of mirror neurons. There is however more. When you think about performing an action, for example by visually

imagining it, patterns are activated that would also be activated if you would actually perform the action (Hawkins & Blakeslee 2004). Our brain is thus activated in the same way (at least to some extent) if you were to perform the action, to imagine you perform the action or to see someone else perform the action. These patterns (including the pathways in which these patterns are instantiated) could be what we refer to when we talk about memes.

Let us see why these patterns fit our concept of the meme. The patterns are genotypic for culture; the possibility to express some behavior depends on the existence of a pattern for such a behavior. Also, the pattern itself is not the behavior. The patterns are replicators; seeing another person perform some behavior creates a pattern for the behavior in the observer's brain. The pattern carries the essence of the behavior, regardless of contingent implementation in one's brain.

Artifacts

Some authors include that memes can be artifacts (art, a book of poetry, architecture, or some other technological object) or can be found inside artifacts (books, movies, etcetera). Earlier I dismissed both these accounts of the meme; the meme is neither a product, nor is it information. In refuting these perspectives I do not disregard the importance of artifacts in cultural evolution. We saw already that transmission goes through phenotype, so it is to be expected that artifacts can also fulfill this role. Not only can they fulfill this role, they can stretch the transmission process over time, beyond the death of an individual. It is via artifacts that Greco-Roman culture could revive after more than a 1000 years in an era that is now called the Renaissance. Artifacts can thus be intermediaries in the replication process. How does this work?

Our brain must somehow process our perception of artifacts in ways that patterns are created; patterns that could become causal for our own behavior or thoughts. Here information becomes important; information is substrate neutral. We recognize in the artifact relational content which is not necessarily dependent on its instantiation; reading about the behavior of an ancient culture could create new memes in our minds. Another way in which artifacts can cause new memes to be created lies in our understanding of an artifact as having been created by another intelligent being. We can conclude that in our perception of the artifact, the abstracted relational content leads to a pattern in the brain of the observer, a pattern that can become causal for the individual's own behavior and thoughts.

3.3 Mechanisms of cultural evolution

In the previous sections of this chapter I established a framework for thinking about memes, the fundamental units of cultural evolution. In this third section I work out how this framework can be used to think about the mechanisms of cultural evolution.

Natural selection

Both memetics and gene-culture co-evolution consider natural selection. I consider biased transmission, the evolutionary mechanism that Boyd and Richerson distinguish, to be part of natural selection as well. I do so because the processes behind biased transmission are psychological in nature, and as far as the individual memes are concerned make up the rules of the environment in which they have to survive.

For natural selection to occur we need four elements: variation, heritability, differential reproduction and scarcity. In cultural evolution, variation and heritability are obvious; different cultures exist (variation) and we can learn new culture by social learning (heritability). The other two elements are however less obvious.

The element of scarcity is related to competition: what do memes 'compete' for? According to Boyd and Richerson, this can either be cognitive resources or the control of behavior of an individual. I think this makes sense, but requires a deeper analysis. We can understand evolution as the story of survival. What then do memes need to survive? This question requires its negative. What ends a meme's *being*? We saw this in the metaphor of the walking path. If a path is not walked on, it disappears. In analogy: if the meme (read: the pattern) is not activated, it disappears. The meme's *being* can also end in another way. The meme disappears if its vehicle, the individual human being dies. To transcend its host's death, it must replicate before that happens. In fact the replication process could extend beyond the death of an individual. We saw this when I discussed the Renaissance. Another example of a meme transcending its host's death is suicide. When the media report on the suicide of a famous person, the suicide meme is spread or reinforced, possibly generating a suicide wave.

Both activation and replication of the meme depend on its host's behavior. Therefore I argue that what memes compete for and what is scarce is primarily the control of behavior. Cognitive resources as Boyd and Richerson distinguish as a target for competition are not the primary target of competition, they are secondary as they require control of behavior. The meme disappears if it is not activated, due to the working of Hebb's law. To appreciate the

effects of Hebb's law on a meme's survival one can think of the need for a biological organism to find food. If it does not succeed in finding food it dies. In the capabilities of a meme to survive in a host, one can recognize the characteristic of longevity, one of the three characteristics Dawkins ascribes to replicators (next to fecundity and copying fidelity).

The element of differential reproduction relates to the ability of the meme to control its host's behavior. While genes that are not expressed, so-called silent genes, are still replicated, memes that are not expressed are not replicated. Another determinant for reproductive success is how well a meme succeeds to come from cultural expression to replication. If a meme is expressed, how likely is it to be copied? Likeliness of being copied depends on the likeliness to be observed. When a meme is observed the meme is automatically copied to the observer's brain. I will come back to what this means for meme success when I talk about emergent phenomena. Likeliness to be observed depends on phenotypic expression of the meme; some behaviors are by their nature more prone to be observed than others[17]. We can understand the ability to be copied as what Dawkins refers to as fecundity. The third characteristic, copying fidelity, I would consider as secondary to fecundity when it comes to natural selection.

Mutation

Copying fidelity is however important for the mechanism of cultural mutation. Mutation is the process in which new replicators are created. One of its sources can be low copying fidelity (low compared to that of genetic replication). Low copying fidelity can be caused by a variety of processes, for example caused by the fallibility of perception. If we misperceive someone's action our brain creates a pattern for the action as we perceive it, not as the action is. Another cause could be the brain's prior patterns. These patterns compete to be activated; what we perceive is interpreted through the patterns we already have. The resulting pattern could be different depending on pre-existing patterns. Low copying fidelity could also occur for various biochemical reasons. Whatever other causes for low copying fidelity can be thought of, the conclusion here has to be that within the process of replication, mutation can occur.

Mutation can also occur after replication. The Darwinian process guided by Hebb's rule could cause an existing pattern to deteriorate. Or, in other cases new neural connections could alter an existing pattern. In both situations the resulting pattern is different from the one which was acquired via imitation. This creates new memes, that themselves can spread. The force of

[17] Bas Haring in fact claims that we think we should be successful because we more often are confronted with people who are successful and the message that we should aim for success, than people who are lazy and the message that it is okay to do nothing (Haring 2007).

guided variation that Boyd and Richerson distinguish falls under this category of mutation. This form of mutation is typically non-random, it tends to be fitness enhancing (or at least is believed to be). This makes sense. The imagining or planning of a behavior depends on a model of the world. Since the model of the world is the result of a huge fact-base, it tends to more often than not to be a good description of reality. If the pattern for the imagined or planned behavior is activated within the model of the world, its connection strengths to other patterns adapt to the model of the world, thereby changing the pattern into a new pattern that tends to be more in line with reality.

Drift

It is not just processes at the level of the meme that influence cultural evolution. In fact what we mostly consider to be cultural evolution takes place at the level of groups of people or populations. The environment plays a large role here. Environmental factors could have nothing to do with the memes and their phenotypic expression. In that case these random (from the perspective of the memes) processes can be ascribed to drift. In other cases they follow from the effects that memes have on the behavior of individuals. Processes grounded in memetic expression can either be ascribed to other memes, or to the meme under investigation. If other memes are unrelated to the meme under discussion, then the processes are random as well and thus are grounded in drift, as it is not the meme itself but its memetic environment that determines its success. If the other memes are related or if the effects can be directly ascribed to the expression of the meme itself, then the emerging phenomenon is grounded in natural selection. Whether natural selection or drift is more important for cultural evolution is a scientific question. It probably depends on the type of behavior under investigation; the more it is expressed the higher is the contribution of natural selection. Culture that is thought to describe a population, can be expected to have many events of expression and transmission. I therefore expect that natural selection is considerably more important than cultural drift.

Success and emerging phenomena

Gene-culture co-evolution and most of memetics focus on emerging phenomena to explain success factors and mechanisms. I now proceed to look at these success factors and mechanisms from the perspective of this metaphysical framework. As I stated earlier, when the expression of two similar memes is observed, both memes are copied. The difference in their success lies in the difference in their subsequent expression in the new host, not in their transmission per se. I think memetics and gene-culture co-evolution consider transmission

incorrectly as a moment of competition. I ground all success factors in Hebb's law: the most activated meme is the most successful (of a set of competing memes). This means that we just need to find out which meme is most activated and observed; we can apply the meme-eye's-view to do this. As I discussed, there are three ways in which a meme is activated: expressing behavior, observing expressed behavior, or imagining behavior. To tell which memes are most successful, we thus have to answer two questions:

1. What factors help an individual to act or think a meme?
2. What factors increase the chance that a meme is observed?

The first question reminds us of the need for memes to be activated in order not to disappear. Factors that help people to think or act a meme can be other memes that have a relation with the meme. This results in Blackmore's observation that memes that have to do with sex and food are more successful. Exactly because people tend to often think about sex and food (since they are triggered by biological needs), the chance is increased that a specific meme that has a relation with these other memes is expressed or activated. This is similar for any memes other than those for food and sex that tend to be activated a lot. If a meme 'succeeds in being activated' whenever another meme is activated (by rearrangement of the neural structure of the brain), its success is increased. This is what also happens with the prestige-bias (also called the model-bias) that Boyd and Richerson defined. The prestige-bias works due to the immediate connectivity of a meme to memes of success (e.g. the meme for being rich, being good in sports, being successful in relationships, etcetera) and fame. Since people often think about being successful, famous or about famous people and their behavior, the meme has a higher chance to be activated. The idea of a meme being activated can also be placed in relation to our view of the world, which itself is a network of memes. Memes that fit in our world-view are more likely to have rich connectivity to other memes. Therefore such memes are more likely to be expressed. This leads to the heuristic that Blackmore calls "copy the most obvious memes". Since our psychologies in general aim for utility maximization, the memetic network that is already in place is able to discriminate for utility. When two similar memes compete for expression, it is the one with the higher utility (in the model of reality that is already in place in the brain) that 'wins'. This is the content-bias of Boyd and Richerson explained in terms of the framework presented in this chapter. The existing prior network of memes that resembles the model of the world also leads to another prediction, namely that the sooner in life memes succeed in becoming part of the model of the world, the less likely they

are to be outcompeted. This shows us why indoctrination is so powerful, but also why youth traumas can be so influential at a later age.

The second question "What factors increase the chance that a meme is observed?" reminds us that memes need to replicate, and thus need to be observed, before their vehicle dies. Factors that determine observation of a meme are the frequency of expression and the amount of people already carrying the meme. The result of both these factors contributes to the frequency-bias that Boyd and Richerson discuss. The heuristic "imitate the common type" can be explained from this framework as well. It follows directly from Hebb's rule: every time we see a behavior expressed, the meme for this behavior is strengthened. The result is that the meme is reinforced and chances are higher we express it ourselves, without requiring any rational decision whatsoever. This is why marketing works. Every time we see an advertisement, the meme that this advertisement corresponds to is strengthened, with higher sales as the result. Link this to factors that increase expression (see the answer to the first question: e.g. sex, food, famous people) and the effect is even larger. One other way to increase observation is to have an anti-meme. For the brain negation of a meme also is an activation of the meme itself. I expect that anti-demonstrations could in some cases the meme they oppose. The abortion meme might actually be helped by anti-abortion demonstrations; people are made more aware that there are other people actually choosing to undergo an abortion.

3.4 Importance

This discussion of the metaphysics of cultural evolution is rather fundamental, as was the purpose of the project from the start. I am confident that as a reader you appreciate the importance of this philosophical discussion, not just for the metaphysics of cultural evolution, but also for cultural scientific enterprise. This perspective however is important for two other reasons, one that has to do with free will, the other with maladaptive memes.

Free will

The implication that our behavior is controlled by memes that are selfish is problematic for the concept of free will. If our behavior is controlled by memes, how can there be something as free will? This is related to the concept of the self, which is according to Blackmore the "the ultimate memeplex" (1999, p219). Blackmore thinks it is illusory: "I ... prefer to accept some version of the idea that the continuous, persistent and autonomous self is an illusion" (1999, p228). This view is not new in philosophy, but in my opinion Blackmore takes a too

radical position; she negates that a self starts with a body. My position is that the concept of the self can be considered to be a meme, but not necessarily a false one. However, even if we 'save' the concept of the self that does not give us free will; this self, that is real, could still be controlled by memes. What choices we make are ultimately determined by the memes that win out in the competition to be expressed. The idea of a free will then comes from a meme itself, a meme that can spread. The choices we make are not free in the sense of having a free will that is not determined, but this does not mean we are not free. If we are a set of memes, then the choice that is determined by the winning meme is still our choice. Being free means self-determination, which is exactly what we do, we, the set of memes we are, determine who we are and want to be.

Maladaptive memes

The second disturbing implication is that some memes are bad for us. I think there is nothing more obvious. Some memes can get you killed, get you in prison, get you a sexually transmitted disease, make you feel unhappy about yourself, let you stay too long with an abusive partner, make you take the wrong mortgage, make you buy the more expensive sweater because it has a brand on it, let you take toxic substances, etcetera. If we are slaves to these memes, we have a problem. When Dawkins first proposed the idea of the meme as a selfish replicator the danger of us being slaves to memes must have been obvious. Completely out of line with the rest of his ideas he however ends *The Selfish Gene* with the following sentence: "We are built as gene machines and cultured as meme machines, but we have the power to turn against our creators. We, alone on earth, can rebel against the tyranny of the selfish replicators" (Dawkins 1976, p 201).

How can we do this, when all we do is determined by selfish replicators? This seems to be impossible, and I think it actually is. It is however only some memes that are problematic, most of them are for our benefit. What exactly our benefit is, is partly determined by the memes that determine us. Let us therefore not focus on what memes are bad, but on what can be done about them. The solution to this problem is reflection. It is reflection that helps us to bring our behavior in line with our interests; in reflection we can determine who we are. This brings me to the ethical importance of this work. Memes can also be understood as maxims, not as a rational thought, but as the material instantiation of the precursors for behavior itself. Reflection changes our maxims, and by that changes our behavior. This works by reinforcing

(or creating[18]) memes that better fit our interests. To define what is in our best interest we can use memeplexes like that of science and philosophical reasoning.

There however remains one problem. How can we, organisms determined by selfish replicators, start this process of reflection? Taking a meta perspective would just be using different memes; all we do and think is memes. Reflection therefore has to be a memeplex as well (even though our capabilities for reflection can be biologically innate). It is to be expected that some people do not reflect, either because they never realized they could or are discouraged to (religious people are for example discouraged to question the existence of a divine being). To be free of the tyranny of (malignant) memes we therefore need to acquire and reinforce the meme of reflection. Reading this work is one of the ways to do so. To be free of the tyranny of bad memes, however, it is better to prevent them from reaching your mind in the first place. An excellent way to achieve this is to get other people to reflect as well; to become free as an individual, we have to strive for all to become free.

3.5 Conclusion

In this chapter I worked out my metaphysics of cultural evolution. I showed that although culture is often thought of as a group phenomenon, it is the processes at the level of the individual that are fundamental. To understand the behavior of the individual I showed that we must distinguish between cultural genotype and phenotype. I declared the unit of cultural genotype to be the meme, thereby sharpening its definition compared to its common use. I asked the question whether it is the unit of cultural phenotype or the meme that is the unit of evolution. I showed that as cultural evolution goes through phenotype, this question has to be answered differently than in biological evolution. For reasons other than causality, which was Dawkins' argument for the gene to be the unit of biological evolution, I consider the meme to be the fundamental unit of cultural evolution. I do so because when we refer to culture, we refer to living culture, culture that is actually practiced by living human beings; it is ultimately not what we find in archeological digging sites that defines who we are today, but the memes that are inside our heads. That said, I do want to stress that I did not dismiss phenotype as unimportant. It is after all cultural phenotype that determines which memes we have in our heads; opposed to biological evolution in which phenotype is 'merely' interacting as a target for natural selection.

[18] See the discussion of cultural mutation.

In the second part I defined the material instantiation of the meme as a brain pattern. I showed how Hebb's rule can be used to think about the state of memes, using the metaphor of a walking path. The fact that the same pattern is activated when we observe, think or act some behavior provides evidence for the view of memes as brain patterns. In the third section I extended this view to the mechanisms of cultural evolution. I defined two ways that a meme's being could be ended: either by no longer being activated or expressed or by not succeeding in being replicated before its host dies. In the latter case this requires observation of the expressed culture by another host. In discussing what factors could prevent the end of a meme's being we arrived at the central dogmas of both memetics and gene-culture co-evolution (e.g. imitate-the-common-type, prestige-bias, etcetera).

In the last part I discussed two disturbing implications of memetics, namely that it is in conflict with the idea that we have a free will and that some memes that define our behavior are actually bad for us. For the implications for our free will I responded that if it is the memes that define us, then we are a set of memes and that any choice we make is still our choice, even though they might not be free in the sense of being undetermined. To the implication that we are (partly) determined by malignant memes I responded that we are free in the sense of self-determining by means of reflection, which is a memeplex in itself. It is reflection, via the use of memeplexes as science and philosophy, that can help us to strengthen those memes that we want as the maxims of our behavior. I finished this metaphysics with a call for universal freedom. To be free of malignant memes it is best if all become free reflecting beings, keeping malignant ideas and behaviors from spreading in the first place.

Conclusion

What is it to be human? We are animals in that we are biological creatures sharing a common ancestry with all life on this planet. Our genetic build-up is the result of a process called evolution, a process that has taken billions of years to produce the organic entities we are today. We are different from animals in that we are not merely determined by our biology; we have culture. Our culture is however also subject to evolution; cultures change. In this work I worked out the metaphysics that gives a fundamental insight in how cultural evolution is possible. The structure of this work represents the three steps that were required: investigation of biological evolution, investigation of existing theories on cultural evolution and the formulation of the metaphysics of cultural evolution.

Biological evolution

The first chapter dealt with biological evolution, the process that defined who we are as biological organisms. Darwin can be considered the father of evolutionary theory. Based on the observation that there is both variation and similarity in life forms, he formulated his theory of natural selection, an algorithmic process that unified all organisms, living and dead. This unification of life can be visualized in the tree of life, a powerful instrument that helps understand historical change. With the tree of life it can be shown that how we usually classify life, namely as species, is somewhat problematic. If species A originates from species B, how do we know whether a certain individual belongs to species A or species B? This requires a subjective decision. Yet in talking about evolution we generally *do* use the species as its vehicle.

Darwin already expressed his doubts about the species concept, since evolution creates both variation and new species by the same process. Perhaps something more fundamental than species is what carries evolution? With the advent of modern genetics it became clear that traits are passed on not directly, but via an entity that carries the blueprint for these traits. This entity and the traits were named genotype and phenotype respectively, with an element of genotype called a gene. This triggered the question whether it could be the gene that is the fundamental unit of evolution. I investigated this question via the concept of the replicator that was introduced by Dawkins. According to Dawkins replicators are the units that survive or do not survive as a consequence of natural selection. This process started already before life was formed, with the selection for stable molecules. The replicator arose with the first (complex) molecule that was able to replicate itself. At some point replicators formed

protective shells and started to cooperate, forming vehicles, entities that exist for the preservation and propagation of the replicators they house. Today, organisms can be considered as vehicles that exist for the preservation and propagation of their genes. The conclusion of my investigation was that while organisms and their traits are the proximate targets of evolution, it is the gene that is indeed the fundamental unit of evolution. The most important argument for this is that changes in phenotype are not causally transmitted to genes; biological evolution is a story of genotype to genotype transmission, where expressed traits merely influence which genes survive the process of evolution.

Knowing what the unit of evolution is, I investigated what are the processes that affect which gene survives and which do not. These processes are the evolutionary forces: natural selection, genetic drift, gene flow, mutation and sexual selection. It is these processes that gave rise to the biological organisms we are today.

Cultural evolutionary theory

In the second chapter the central topic was culture, the part of our behavior that is not determined by our genes. I investigated two disciplines that view cultural evolution as a Darwinian process: memetics and gene-culture co-evolution.

Memetics originated when Dawkins extended his replicator idea to culture. He wondered if there are other replicators than genes and concluded that culture has its own replicators: memes. Memetics, perhaps due to this origin, has a close analogy with genetics. Memes are discrete units of culture that have just one 'purpose': survival. To find out what makes a meme survive, memeticists use the meme's-eye-view: taking the perspective of the meme and wondering what would increase or decrease a meme's success. Factors that influence meme success are the content of the meme, who carries the meme and our evolved psychologies. The meme's-eye-view has been applied by Blackmore to several domains, for example to assess what makes religions so widespread and to explain why alternative medicine is so popular even when it makes false claims. These and other examples in Blackmore's book show that memeticists seek for rapid application of their theory, perhaps at the cost of finding empirical evidence for its claims and maturing its theories. This might be the reason why the domain not so active anymore.

The other domain gene-culture co-evolution has a much stronger focus on methodology. It brings together biological and cultural evolution in one (mathematical) framework. This is contrary to memetics that considers biological evolution to be irrelevant in the modern day

society. The pioneers of gene-culture co-evolution, Boyd and Richerson, are much more cautious in using the analogy of genetics in cultural evolution. I think they are too cautious, up to the point that it is not clear how the separation between cultural genotype and phenotype that can be extracted from their definition of culture translates to the rest of their theory. Nevertheless it is gene-culture co-evolution that is currently the more active research domain of the two. I do however think co-evolutionary theorists should find more concrete cases to apply their theories to, but I expect there are plenty of researchers from fields with a stronger basis in empirical data that will happily offer collaboration

The metaphysics of cultural evolution

In the third chapter I formulated the metaphysics of cultural evolution. This metaphysics gives an answer to the question how cultural evolution is possible. I started by limiting the scope of this project to the level of the individual. I argued that it is this level that is most important, since it fundamentally determines phenomena at higher levels like that of the group or population. I also did not venture into the domain of (cultural) niche construction, since despite that it is important for sociology and a historical account of culture, it cannot explain variation in behavior within a (cultural) niche.

Culture refers to all kinds of concepts, for example behavior, art, believe-systems, traditions, etcetera. Since these concepts are fundamentally different they can only be unified by considering something that is causal to these concepts, cultural genotype. This line of reasoning made me conclude that it is necessary to distinguish between cultural genotype and phenotype. Analogous to the gene, I defined the element of genotype as the meme. For a meme to be able to give rise to a phenotype, the meme must have a material instantiation, which I include in my definition. This is a sharpening of the concept of the meme that is commonly used for both phenotype and genotype or as a unit of cultural information (lacking a physical form).

The important difference between biological and cultural evolution is that in cultural evolution replication proceeds through phenotype. This makes phenotype in culture more important than its biological counterpart, which is 'merely' a proximate target of selection. But is the meme nevertheless, like the gene in biological evolution, also the unit of evolution? The argument for the gene to be the unit of evolution, that there is no causal arrow going from phenotype to genotype, does not hold for culture. When we talk about culture, we however imply culture that is actually expressed. It is not what we find in archeological digging sites that defines who we are, but the memes that reside in our brains. Therefore I conclude that

even though cultural phenotype is important for cultural evolution, the fundamental unit of cultural evolution is the meme.

The next step was to define the meme's material instantiation, which I argued is a pattern (or neural pathway) in the brain. This is supported by the fact that the same pattern is activated when one thinks about an action, acts out an action or sees someone else perform the action. Our unique cultural abilities might be related to mirror neurons and to our symbolic capabilities, though the latest research is not conclusive. For the description of dynamics of the meme this is however not required. I argued that Hebb's law is central for understanding the dynamics of memes. With the metaphor of a walking path I discussed that memes need to be activated in order to survive in the brain. Furthermore, as the memes die when their host dies, they have to be expressed and observed in order to survive. I showed that analyzing the two ways in which the existence of a meme can end leads to the central dogmas of memetics and gene-culture co-evolution.

The metaphysics of cultural evolution has two disturbing implications. It seems that if our behavior is determined by our genes and memes there is no such thing as a free will. Also, memes are selfish, which allows that some of the memes are actually bad for us. To the implication that we have no free will, I responded that if who we are is a set of memes, then our behavior that is determined by this set of memes is still our behavior. To being determined by malignant memes I argued that there are memeplexes that allow us to reflect. Via these memeplexes such as science or philosophy we can self-determine which memes win out in the control for our behavior; in that sense we are free beings. Another approach is prevention: if others reflect and thereby inhibit the expression of malignant memes, these malignant memes do not reach our minds in the first place. In order to become free we must strive for universal freedom.

"The highest possible stage in moral culture is when we recognize that we ought to control our thoughts."

Charles Darwin (1871, p101)

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