University of St Andrews
School of Psychology and Neuroscience, and Department of Philosophy

What Kind of Mind?

Lesson 2: Teacher Notes

Lesson 2	Activity Instructions	Purpose
1	**Recap Lesson 1** **Resources: Slides 1 and 2 of PP** **Instructions:** In the previous lesson, we thought about what sorts of things might be intelligent and why we might think they are intelligent. We thought about different types of animals and their minds. We also thought about whether the mind is the same as the brain and what some philosophers had to say about this. We then went on to think about different question we might ask our experts.	To reinforce main ideas from previous lesson.
2	**Evolution: Introduction to Evolutionary Theory** **Resources: PowerPoint Slides 3-4 Film embedded in PP Slide 4** **Whole Group Discussion:** General discussion and opportunity to ask questions of the film and each other Theory of Evolution Film: https://www.youtube.com/watch?v=BcpB_986wyk **Background:** This introduction to evolution builds upon the activity in the first lesson. The children have just been acting and thinking in creative ways as 'bat scientists'. This has helped them to look at human beings in a novel and exciting way. A real-life scientist who looked at life in a creative way was Charles Darwin. His way of thinking about animals was revolutionary and changed how we think about life on earth. Show the film and invite comments from children. Humans are a distinct species of great ape family. We share many points of commonality with apes and other primates, such as monkeys. The animals we are today have evolved over millennia from primates, as a result of the process of natural selection. As this process repeats and continues, new species form. Humans developed as a result of selection in bipedalism and language, which allowed us to walk on two legs and to talk. We only want to convey the very simple idea that (1) among any population, there is a range of characteristics (some group members are bigger than others, some differ slightly in colour, shape, etc.); (2) environmental conditions can make it the case that creatures with certain features are more likely to survive and reproduce; (3) over time, this can result in a change to the range of characteristics in the population (for example, if bigger, darker animals survive and reproduce, then eventually all of the animals will be big and dark). This is Darwin's idea of "survival of the fittest".	To introduce evolutionary theory, natural selection and survival of best fit to the environment.

3	**Evolution: Which characteristics are best suited to which environments?** **Resources: PowerPoint Slides 5-7** Image of beakless finch from PP Slide 5, individual worksheets with beakless finch; film of woodpecker finch embedded in PP Slide 6 (also below); images of finches and foods in PP Slide 7 Woodpecker Finch film: https://www.arkive.org/woodpecker-finch/camarhynchus-pallidus/video-00.html **Background:** This activity follows on from the film about Darwin's theory of evolution and his research with finches. The idea is to help the children make informed guesses as to what shape of beak would allow the finch to retrieve the grub from under the tree bark. By asking the children to think about this, they are embedding ideas about best fit to the surrounding environment in a particular species. They are also learning the beginnings of formulating a hypothesis, by generating a 'best guess' as to what will fit and why. **(a) Individual Exercise - Beakless Finch Worksheet** **Instructions:** Give children **worksheet** - 'beakless' finch template – ask them to draw the beak that could get grubs from under tree bark. What shape would the beak be to be able to fish out the worm or grub from under the tree bark? How long would it be? Would it be a certain colour? **Now show the children the film of the woodpecker finch**, which uses a cactus spine as a tool. Invite reactions from the children. What did they think of the woodpecker finch's behaviour? Can we say that the woodpecker finch is using a tool to get its food, much as we would use tools to help us get food (for example some humans use spears when hunting)? Does this mean that the woodpecker finch is intelligent? **(b) Whole Group – Match the finch to the correct food** **Instructions:** Using the images on the PP Slide 7 of the different finches, invite the children to match the correct bird with its preferred food. How did you know which bird eats which food? What about the shape of the beaks helped you to match it with the food? Did you make a guess about which beak? How could you test your guess to see if it is correct? **Draw activity to a close by asking:** Does this mean that the woodpecker finch is more intelligent than the other species of finches?	To test understanding of survival of the fittest.
4	**Scientific Method: How do scientists find out?** **Resources: Slides 8-11** Images embedded in PP, teacher explanation **Whole group discussion – How can we find out if one species of finch is more intelligent than another group?** **Background:** This task introduces scientific method and demonstrates the various stages that a researcher will go through to test an idea. The scientific method is the ordered way that scientists will carry out research	To examine how scientists begin and continue to form their ideas.

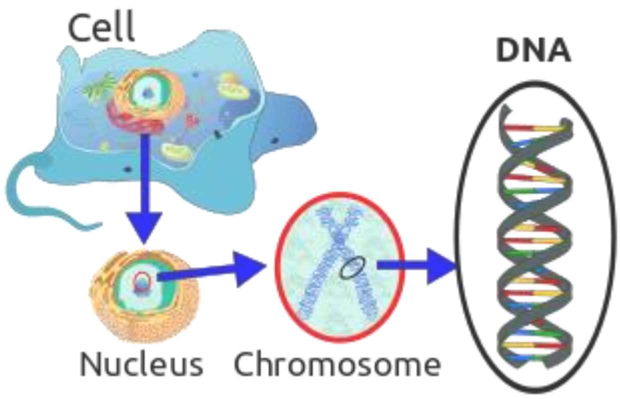
	and try to find answers to their questions. Most scientists follow this process when setting out to test their ideas. The order of the steps in the scientific method is important for reliability and allows the research to be replicated if required. **Slide 8** shows a researcher at the Edinburgh Zoo Living Links Centre working with squirrel monkeys. The monkeys are free to come into the research room if they wish and take part in the experiments. They volunteer and so they are not forced to do the research. Visitors to the zoo can go and watch the research taking place. **Slide 9** shows a researcher running her experiment with chimpanzees at the Budongo Research Unit at Edinburgh Zoo. The smaller screen on the right shows a chimp reaching up to a touch screen to take part in the experiment. Visitors are welcome to go and watch the research taking place. **Slide 10** – This sets out the scientific method as a flow diagram. **Slide 11 -** The idea that one type of finch may be more intelligent than another is then applied to the scientific method as an illustration. **Instructions:** Introduce the scientific method using the slide (question, hypothesis, experiment, results, interpret). **Explanation:** Explain that this is the way that scientists will research and try to find answers to their questions. Most scientists follow this process when setting out to test their ideas. Notice the different parts of the method and the order in which they are carried out. It is important to follow this same order to ensure that the scientific tests are trustworthy and the results reliable. Following the exact order is important and necessary if the tests need to be repeated at a later date. A hypothesis is a kind of educated guess, or a good prediction, which will then be analysed, to see if it explains the results of the experiment. Ask the children: How can we find out if one finch is clever than the others? Can we compare finches by giving them tests to do? What would the tests be like? Can the finches choose the right tool? We've included a slide that describes the scientific method in an abstract way. Many groups will be quite familiar with this; for those that aren't, here are some things to stress. Our basic goal is to try to investigate some *question*, and in order to do that we are going to try to *test* a particular claim that bears on that question. The claim we are testing is called the *hypothesis*. We want to devise a test -- an *experiment* -- and we want to use the hypothesis to make a definite *prediction* about what will happen in the experimental scenario. If that prediction turns out to be true, that is some evidence for the hypothesis; if the prediction turns out to be false, that is some evidence against the hypothesis. However, the situation is often complicated: perhaps there is some other explanation of why we got the results we did. So we need to *interpret* the results.	

	In the next slide, we include a detailed example. Some finches use tools, others don't. The experiment was designed to investigate the question of whether there is something special about the minds of the finches that use tools. Have they evolved a new kind of intelligence? Or are non-tool-using finches equally intelligent (suggesting that all the finches evolved from an intelligent ancestor)? The finches were presented with a transparent box, through which they could see two curved canes and two pieces of food, arranged in one of the ways depicted in the slide. (In the drawing on the slide, the round dots represent the pieces of food.) They could retrieve the food only by pulling on the canes. The birds had to choose which cane to pull; one would deliver the food, and the other would not. An intelligent creature should be able to learn to choose the correct cane. If tool-using finches are more intelligent, we would expect them to do better on this kind of test; that is our hypothesis. More specifically, the hypothesis predicts that tool-using finches will learn to choose the correct cane more quickly. But this prediction turns out to be wrong: non-tool-using finches learned equally quickly. So, we have some evidence against the hypothesis. We can see how the experiment maps on to the scientific method in this slide. Result of study = all finches can learn and choose tools equally well. The hypothesis that woodpecker finches will perform better is not confirmed. One conclusion we might want to draw is that the ancestor finch was a good learner and passed this ability on to all of its descendants.	
5	**Plenary** **Resources:** PP final slide **Instructions:** Recap the main points of the lesson as follows: We saw how Charles Darwin asked interesting and new questions to create his theory of evolution and how he studied finches as part of this. We then thought about different types of finches and how they are suited to their environments. We thought about the scientific method which scientists use in their work and how this was used to test the intelligence of finches. The study of animal minds is quite new and there are still lots of unanswered questions!	To revisit key themes of the lesson.

A Brief Guide to Evolution

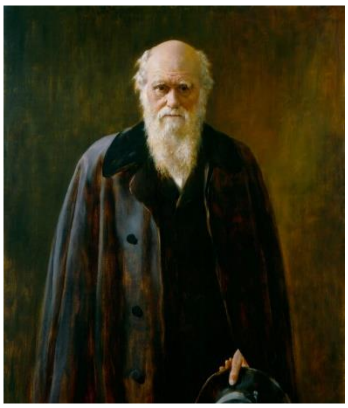
The story of evolution began approximately 4 billion years ago with simple, single-celled microorganisms, which resulted from many biochemical interactions in large bodies of water. Since then, over incredibly long periods of time, the diverse forms of life evolved to inhabit myriad different environments. This guide will delve into the concepts and terminology behind evolutionary theory, as well as its importance to the study of human and animal minds.

To begin with, we must address how genes stored in our DNA are vital to the process of evolution. Although the structure of DNA was discovered in 1953, long after naturalists began understanding how evolution works, this discovery has greatly broadened our understanding of how organisms change over time.



Each of the cells in your body contains genetic material in the form of deoxyribonucleic acid, or DNA. This compound serves as a 'blueprint' for how you develop over time, influencing your behavioural and physical traits, as well as the diseases to which you may be susceptible. Genes, however, are not always perfect indicators of how a person will look and behave; there are many environmental factors which also contribute to these things. Genes impact your body and behaviour, but your body and behaviour can also change the way your genes are expressed. For instance, if someone carries a gene that makes them more predisposed to having lung cancer, but they live healthily, they will probably never develop this disease. However, if they take up smoking, they will be much more likely than others to provoke the growth of a cancerous tumour. Genetic expression is a complex process with millions of interacting factors, but there is no doubt that genes are integral to how our bodies and minds come to function.

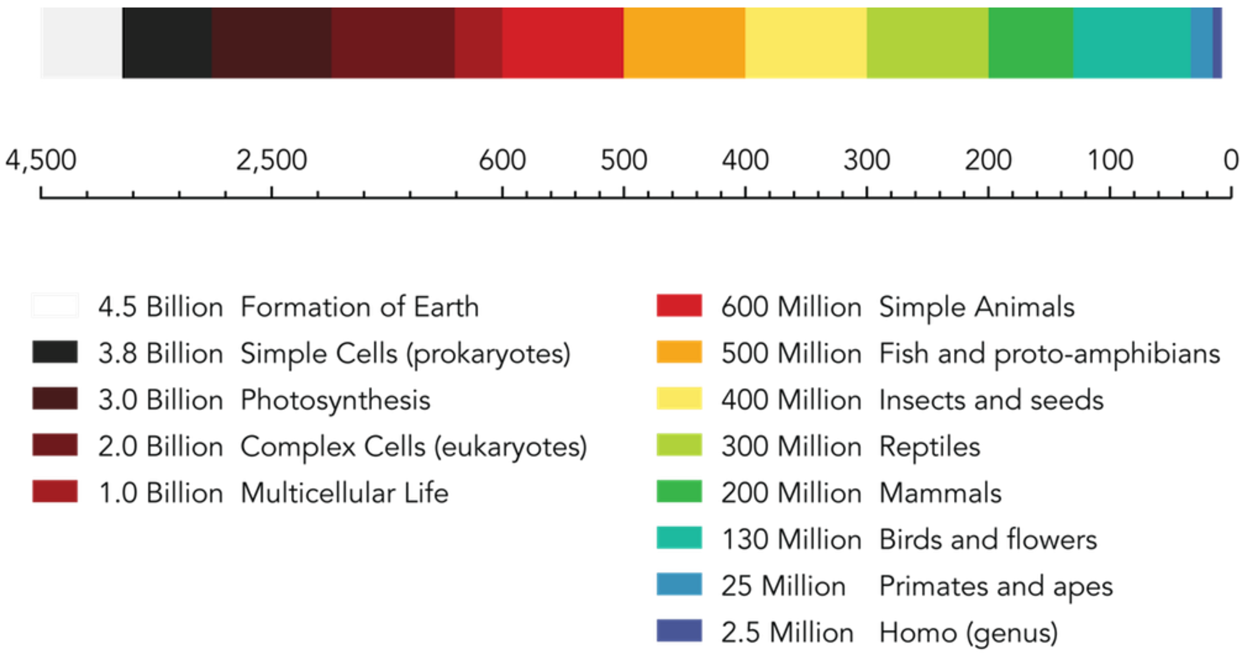
Each individual inherits half of their DNA from their mother, and half from their father, and thus also contributes half of their DNA to the genetic material of their own children. This is important: the person with whom you choose to procreate influences half of your child's genetic makeup. Because we want our children to be healthy, we will tend to choose partners who display healthy physical traits, which reflect more robust genes. Though we cannot look at someone and know their exact predispositions to every disease, we have evolved the ability to look at some features and determine how *likely* they are to be healthy. If you reproduce with someone whose genes give them healthy traits, your children will be healthier, and therefore more likely to pass on these genes to their children. And so on, and so on… Since the dawn of time.



Charles Darwin (1809-1882)

You can think of evolution as a generational process of elimination. Individuals with genes that suit their environment live long enough to pass on their genetic material to their offspring, while those who do not swiftly exit the gene pool upon their earlier death. Charles Darwin, a nineteenth-century naturalist famous for his research into evolution, called this process *natural selection*: individuals unfit for their environment die off before reproducing. It is worthwhile to note that the organisms that survive are not necessarily the strongest, or the most intelligent—they simply need to be fit for their environment. In other words, if your environment is a coral reef, high levels of intelligence won't help you if you have not evolved the means to breathe underwater.

Evolution happens over the course of millennia, and it takes many iterations of natural selection for one species to evolve into something different, if environmental pressures demand it. This unfathomably intricate process is what has allowed for the millions of different species which exist today to evolve from the simple lifeforms that existed billions of years ago. Evolution can happen both slowly and in punctuated bursts, but compared to the human historical record, this ancient process progresses at a glacial pace. Humans are a very, very new species, as far as evolution is concerned. Our genus, *Homo*, evolved a mere 2.5 million years ago!

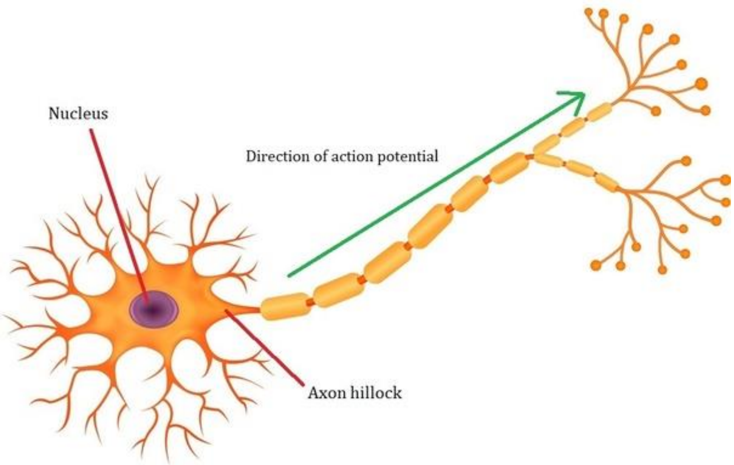


Evolution of the Mind

In the same way that bodies evolve, so too do minds. The truth is, we don't have much direct evidence about the physical organisation of ancient brains—while we have clear fossil records of ancient skeletal matter, we have no fossil records of the fleshy, fatty material found in brains, as it disintegrates before it can fossilise. However, we can still infer a lot from the physical attributes (such as skull size) and chemical compositions of the fossilised remains we do have, as well as the things that our own ancestors created and left behind.

The evolution of brains has its roots in the evolution of chemical signalling—something that has been around since the earliest existence of single-celled organisms. To maintain their function, regular cells in our bodies move different chemicals across their membranes, in a process that can take minutes. However, there is a faster way to accomplish this: by generating electric potentials. This is how brain cells (neurons) communicate with one another, and it is a process which can be observed in organisms as simple as the sea sponge. Indeed, many of the components needed to electrically transmit signals are even present in single-celled organisms called choanoflagellates, which evolved 850 *million* years ago! From that point forward, cells evolved to become more specialised in the types of electric messages they could convey, and the first nervous systems evolved not too long after.

We also have evidence of the sophistication of our ancestors' minds from the things they left behind. Tools like spears and oil lamps give us insight into how their communities were organised, and how they may have conducted their lives on an everyday basis. Things like cave paintings and burial sites illuminate some of the cultural tendencies of early humans, as well as the ways in which they may have communicated ideas to others.



Propagation of an electric current (action potential) across a neuron

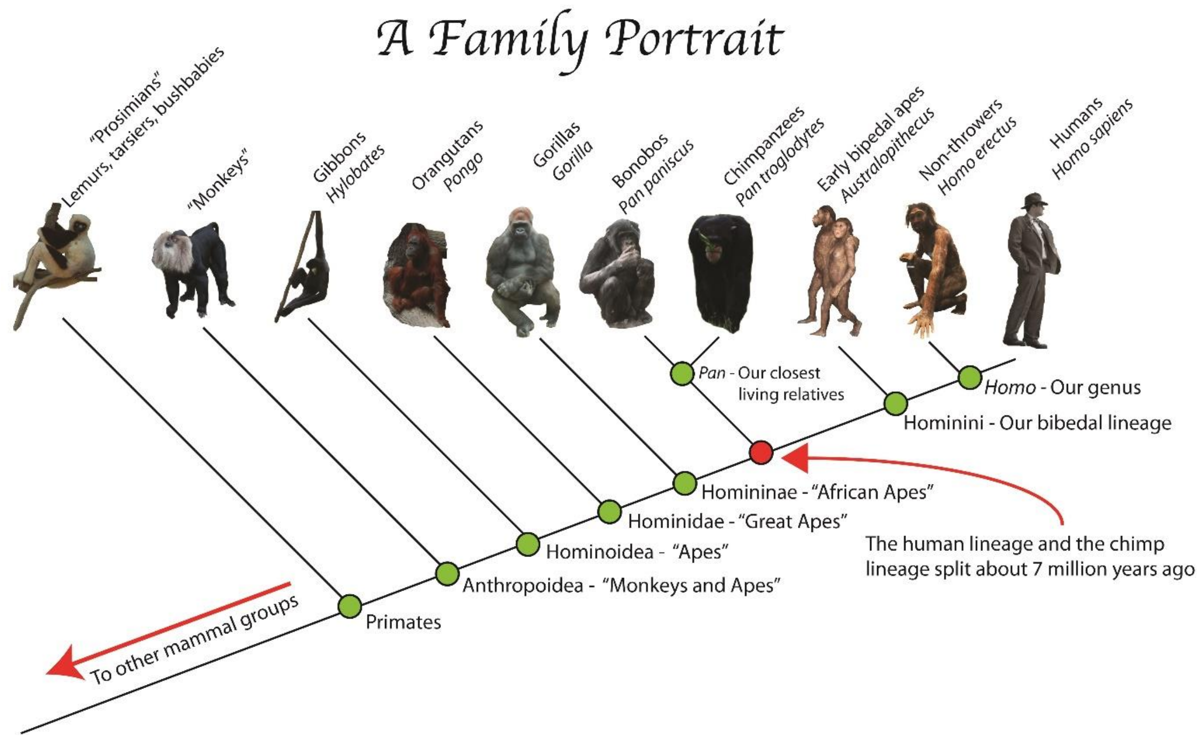
This also provides information relating to how the human mind may have evolved, as well as how 'modern' our brains truly are. What we know is that the human brain likely did not evolve much since *Homo sapiens* emerged as a species. While we are of course more technologically advanced than these ancient peoples, our minds are more similar than popular culture (and the trope of a 'knuckle-dragging' caveman) would have you believe. Humans, it seems, have specifically evolved the physical and mental faculties needed to make tools, innovate, produce language, and form social groups.

What can animals teach us about the evolution of the mind?

To understand the evolution of human intelligence, it is sometimes helpful to look at how the minds of our closest evolutionary relatives operate. As we share as much as 98% of our DNA with other great apes (chimpanzees, bonobos, gorillas, and orangutans) and because we have a recent common ancestor, we can expect to share some cognitive and behavioural traits, too. Bonobos form very cohesive social groups, and chimps have been shown to use tools and engage in social learning. In 2018, researchers at the University of St Andrews even found that wild orangutans actively communicate about the past, vocally warning their offspring about a predator after the predator is gone.

Our minds, as well as the minds of all other animals, evolved to function appropriately in their given environments. By inspecting how animal minds operate, we can infer things about their environments—namely, how might they engage with other individuals and the resources to which they have access. Evolution functions on a basis of cost and benefit; after all, it takes a great deal of energy to run a big brain, so there must be a reason why certain animals have large, complex brains while others do not. The evolution of a large brain is justified if the enhanced cognitive capacity it gives helps an individual acquire more resources to maximise the chance of overall survival. Thus, brains and their environments influence each other: larger-brained species may be able to plan ahead, efficiently extract food, and outsmart predators, and these behaviours impact the organisation of the environment, further causing gradual changes in the brain.

The organisation of animal brains can also inform which neural areas help animals behave in certain ways. For instance, some researchers believe that a larger neocortical ratio (the ratio of the frontal section of your brain, called the frontal cortex, to the rest of your brain) explains why some species can integrate a large amount of social information and solve complex problems, whereas others cannot. The fact that we and other apes share the ability to form social groups and dominance hierarchies suggests that our common ancestor, an extinct primate which preceded modern species, also possessed these traits.



Evolution reveals the beauty and complexity of life on Earth. The fact that all biological change is driven by a few definable (yet inherently chaotic) forces shows that even a few mathematical rules governing the universe can generate dizzying, kaleidoscopic variety in everything we see. Patterns emerge from chaos, and webs of causal influence stretch to encapsulate all things in our incredible environmental macrocosm. Some may argue that evolutionary theory takes the wonder out of life—and this could not be farther from the truth. From single-celled prokaryotes to the astounding biodiversity we see today, constantly diverging and shifting according to environmental pressures, we witness a transformation billions of years in the making. In appreciating this fundamental process, and informing ourselves of the capabilities of animal minds, we can act with consideration for the environment, using our cognitive powers to promote good.