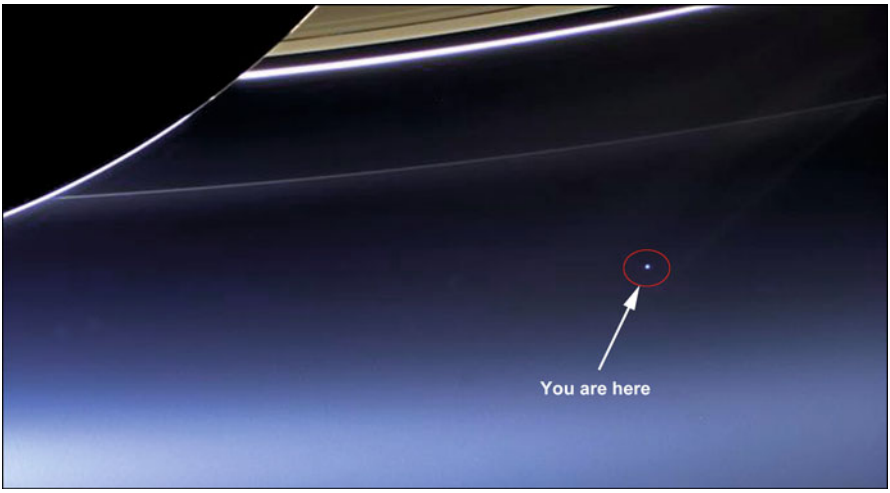
# Pale Blue Dot




**Pale Blue Dot** The Earth seen through the rings of Saturn by the Cassini spacecraft

> "Look again at that dot. That's here. That's home. That's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives. The aggregate of our joy and suffering, thousands of confident religions, ideologies and economic doctrines, every hunter and forager, every hero and coward, every creator and destroyer of civilization, every king and peasant, every young couple in love, every mother and father, hopeful child, inventor and explorer, every teacher of morals, every corrupt politician, every "superstar", every "supreme leader", every saint and sinner in the history of our species lived there – on a mote of dust suspended in a sunbeam.
>
> It has been said that astronomy is a humbling and character-building experience. There is perhaps no better demonstration of the folly of human conceits than this distant image of our tiny world. To me, it underscores our responsibility to deal more kindly with one another, and to cherish and preserve the pale blue dot, the only home we've known".
>
> (Carl Sagan 1994)



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## Definitions

**adaptation:** those properties of an organism that enable it to survive and reproduce in its natural environment.
**active agents:** supernatural or natural entities that influence natural events
**agenticity:** the human tendency to infuse patterns with meaning, intention and agency.
**agnostic:** a person who thinks that nothing can be known about the existence or non-existence of the supernatural.
**anthropic principle:** the collective name for a group of ideas that assert that physical and chemical theories about the Universe must take into account the existence of human life.
**archaea:** a group of prokaryotic organisms distinguishable from bacteria by several biochemical properties.
**assertion:** the declaration that something is true.
**assumption:** the position that something is true for the purpose of argument or action.
**atheist:** a person who does not believe in the existence of the supernatural.
**bacteria:** a group of prokaryotic organisms, distinguishable from archaea by several biochemical properties.
**belief:** a statement of faith that an idea is true or important, whether or not there is testable evidence for it.
**billion:** one thousand million
**biodiversity:** the existence of many different types of organism.
**biogeography:** the study of biodiversity across all regions of the Earth.
**biosphere:** that part of the Earth that contains living organisms.
**Cambrian explosion:** the relatively sudden appearance of muliticellular organisms about 540 million years ago in the fossil record.
**crystallins:** transparent proteins found in eye lenses.
**cyanobacteria:** a group of photosynthetic bacteria.
**deism:** the belief in a supernatural agent who created the Universe but no longer interacts with it.
**DNA:** deoxyribonucleic acid.
**ecosystem:** a system of interacting organisms and their environment.
**elongation factor:** a protein required for ribosomes to synthesize polypeptides.
**empirical:** derived from observation or experiment and not from what someone tells you.
**endosymbiosis:** one type of cell living inside another type of cell without harming it, and possibly providing some benefit.
**enzyme:** a biological molecule that catalyses a chemical reaction; most enzymes are proteins but some are made of RNA.
**eugenics:** the idea that humans should take steps to improve their genetic inheritance.
**eukaryotes:** organisms whose genome is surrounded by a nuclear membrane, thus separating transcription from translation.

**evolution:** the change in genetic composition of populations with time.
**extant organism:** an organism that occurs today.
**extinct organism:** a species that has completely died out.
**eyespots:** structures that detect the intensity and direction of light but are unable to form an image.
**facts:** in science, facts are observations that are empirical, repeatable, and shareable by everyone.
**faith:** belief in religious doctrines.
**fitness:** in evolutionary theory, fitness is defined as the mean number of offspring left by an individual, relative to the number of offspring left by an average member of the population.
**genes:** regions of DNA that encode RNA and protein molecules.
**genetic code:** the relationship between the sequence of bases in DNA in a gene and the sequence of amino acids in the encoded protein.
**genetic drift:** the change in gene frequency between generations caused by random sampling effects.
**genetic system:** any system that contains DNA, the enzymes to transcribe the DNA into RNA, and to translate the sequence information into proteins.
**genome:** the total genetic information in a given organism.
**homology:** in Darwin's time, 'homology' described similar organs in different species, but today is often used to describe structures or molecules that are evolutionarily related.
**hominid:** a member of the great apes which includes gorillas, orang-utans, chimpanzees, bonobos and humans, and their extinct ancestors.
**hominin:** a member of all the primates from modern humans to the last common ancestor of humans and chimpanzees.
**hypothesis:** an imaginary but testable speculation that might explain some facts.
**intentionality:** the tendency to interpret events in terms of purpose.
**lateral gene transfer (LGT):** any process in which an organism incorporates genetic material from another organism, without being a direct descendent of that organism.
**macroevolution:** evolutionary change which produces new species.
**messenger RNA:** the product of transcription that is used by ribosomes to make proteins.
**metabolism:** the totality of chemical and physical reactions occurring inside organisms.
**metaphysical naturalism:** the assertion that the supernatural does not exist.
**methodological naturalism:** the assumption that scientists make that all that exists is the physical world that is characterised by unvarying regularities ('laws of nature') that can be studied by observation and experiment.
**microevolution:** evolutionary change occurring within species.
**micron (micrometre):** one-millionth of a metre
**monotheism:** the belief that there is only one supreme supernatural agent.
**mutation:** a change in the base sequence of DNA.
**Mya:** million years ago

**natural selection:** changes in the genetic composition of a population due to differences in survival and reproduction.

**naturalism:** The assumption that everything there is belongs to the physical world we all aware of and which behaves according to unvarying regularities.

**NOMA:** an acronym for 'non-overlapping magisteria', an idea suggested by Steven Gould that asserts that religion and science deal with different areas of human experience and thus cannot comment on each other's concerns.

**Occam's razor:** When several different explanations of a body of evidence are possible, prefer the one with the smallest number of assumptions, not because it is more likely to be correct but because it is the best way to proceed; the defining principle of science, also known as the law of parsimony.

**occasional theism:** the ability of some scientists to switch between naturalistic and supernatural types of explanation.

**patternicity:** the human tendency to see meaningful patterns in both meaningful and meaningless noise.

**photosynthesis:** the conversion of absorbed light energy to chemical energy.

**plastid:** a type of membrane-bound organelle found inside all plants, the most obvious and the most studied being the chloroplast.

**polypeptide:** a chain of amino acids in a defined sequence.

**polysome:** a molecule of RNA bound to more than one ribosome.

**polytheism:** belief in more than one supernatural agent.

**prokaryotes:** organisms whose genome is not surrounded by a nuclear membrane, enabling translation to be coupled with transcription.

**protein:** a molecule consisting of one or more polypeptide chains.

**pseudogenes:** genes that have lost their original function due to mutation.

**random mutation:** the observation that which particular mutations occur are unrelated to their effects on evolutionary fitness.

**reason:** the intellectual faculty by which conclusions are drawn from premises.

**regulatory gene:** a gene that encodes either a protein or RNA molecule that binds to another gene or genes and controls it or their expression.

**religion:** Belief in a superhuman controlling power or powers, existing in an invisible supernatural realm and entitled to obedience and worship.

**rhodopsin:** a membrane-bound protein-retinal complex that absorbs light.

**ribosomes:** universal intracellular structures that synthesize proteins.

**RNA:** ribonucleic acid.

**science:** A set of ideas about the Universe based on empirical evidence, the use of Occam's razor, and the assumption that natural events have only natural causes.

**secularism:** the assertion that governmental institutions and policies should exist separately from religious beliefs and practices.

**separate creationism:** the hypothesis that species arose separately and independently by natural means; should not be confused with 'creationism', 'creation science' or 'intelligent design', which are religious assertions.

**species:** a population of organisms that can potentially or actually interbreed; applies principally to eukaryotes.

**supernaturalism:** the assumption that beyond the obvious physical world there lies another invisible world containing one or more active agents.

**theism:** the belief that at least one supernatural agent created the Universe and continues to interact with it.
**theory:** in science, a theory is a coherent conceptual model that explains whole sets of facts and withstands predictions that could falsify it.
**transcription:** the enzyme-catalysed process by which one strand of the DNA of a gene is used as a template for the synthesis of a molecule of RNA with the same base sequence.
**transcription factor:** the product of a regulatory gene.
**transformism:** the hypothesis that all species arose independently but changed with time.
**transitional fossils:** fossils that show a combination of features from both their presumed ancestors and their presumed descendants.
**translation:** the process by which ribosomes use the base sequence in a molecule of messenger RNA to synthesize a polypeptide chain with a defined amino acid sequence.
**uniformitarianism, principle of:** the assumption that natural processes observed to be operating in the present also operated in the past.
**unvarying regularities:** another name for 'laws of nature', used to avoid the misinterpretation that laws necessarily imply a lawgiver.
**vestigial structures:** structures that are reduced in complexity and function compared to similar structures in other organisms.
**Wallace Line:** an imaginary line in the ocean that indicates the separation of land species between the southeastern and northwestern parts of Indonesia.

## Suggestions for Discussion Topics

1. What sort of empirical observation would persuade you that Darwin's theory of evolution is false?
2. Can you think of any ways of explaining the world other than naturalism and supernaturalism? Can you test any of these alternative explanations?
3. Discuss the four postulates that Darwin made in order for natural selection to operate (see Chap. 4). What would be the effect on a population if postulates 1, 2 and 3 are correct, but postulate 4 is incorrect? Could natural selection operate if postulates 1, 3 and 4 are correct, but postulate 2 is not?
4. What is your view of those religious scientists who alternate between naturalistic and supernaturalistic explanations of the world? Does consistency of behaviour matter?
5. Discuss why mutation is random, but natural selection is nonrandom.
6. Conduct a survey of your classmates about what they believe about the nature of the world, and why they believe it. Then conduct another survey of what they think other people believe and why they believe it. Compare the surveys with each other.

7. Can you think of any empirical observation you could make or experiment you could conduct that would persuade you that supernatural agent(s) exist? Are you aware of any such observations or experiments?
8. Assume for the sake of argument that evolution is the invention of a supernatural agent, rather than a natural process. From your knowledge of how evolution works, what might you deduce about the character of that agent?
9. Compare the different lines of evidence for evolution outlined in Chapter 5. Which do you regard as the strongest evidence and which the weakest? Can you think of any other ways in which the theory of evolution could be tested?
10. Suppose that mutation is not random, but directed to create useful adaptations. From your knowledge of how the genetic code is used to make proteins, how might you explain such a hypothetical process of directed mutation, without invoking supernatural agents?
11. Some religious scientists argue that the 'laws of nature' have been created by a supernatural agent, while atheistic scientists point out that natural laws, by definition, have only natural causes. Which of these positions makes more sense to you? Explain why.
12. Suppose that no evidence has been found to support the idea of evolution. Given that both mutation and natural selection are observable facts, how might you explain this absence?