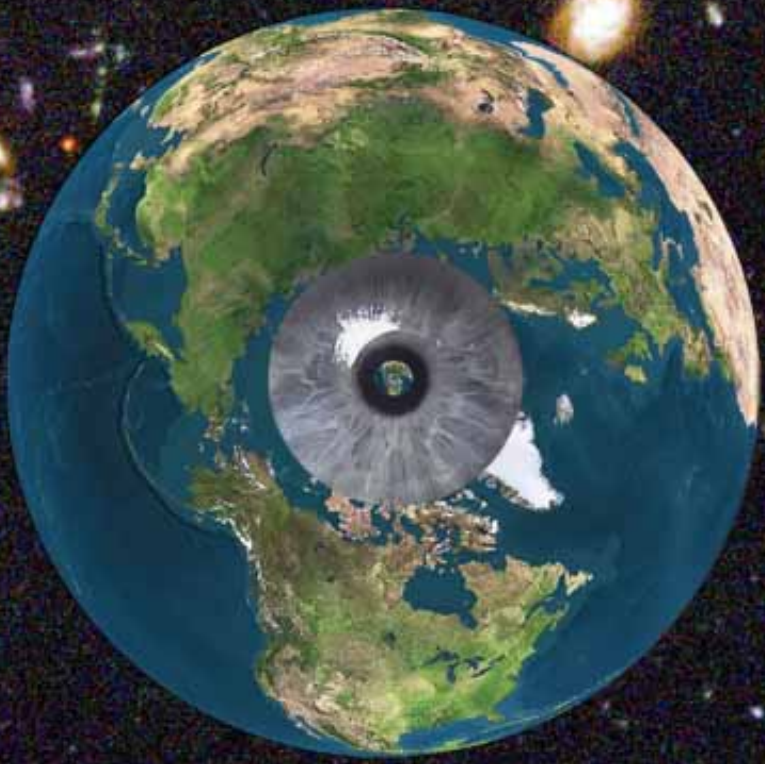
Human Knowledge

Foundations and Limits



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Human Knowledge:
Foundations and Limits

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- Why is there something rather than nothing? Might the world be an illusion or dream? What exists beyond the human senses? What happens after death? Does divine or supernatural agency exist? Is the future already decided?
- What is the meaning of life? What is right and wrong? Is the world good or bad? Are humans good or evil? What beings should have what rights? What should one do?
- What is truth? consciousness? intelligence? What are the limits of intelligence? Of logic? Could a machine think? Does free will exist?
- How and when did the universe begin? What happened before it began? How and when will the universe end?
- What does the universe consist of? What laws govern it? Why is the universe this way?
- How big is the universe? Does it have a center or edge? What is outside the universe? Are there other universes?
- What is life? How did life arise? What explains its complexity?
- How did mind and language arise? How does the brain work?
- Is there life and intelligence beyond earth?
- What political system works best? What economic system works best?
- Why do human individuals, groups, and sexes behave as they do?
- Why have some human societies experienced more material progress than others?
- Will humanity suffer cultural decline? economic crash? tyranny? resource depletion? overpopulation? runaway pollution? pandemic? interplanetary impact? nuclear catastrophe? nanotech plague?
- Will humanity experience divine salvation? loss of faith? paranormal abilities? alien contact? time travel? warp travel? machine or human superintelligence? immortality?
- What will happen in the next: hundred years? thousand years? million, billion, and trillion years?

This living hypertext is a systematic statement of what humanity does and does not know, and can and cannot know, about the answers to these and hundreds of other such questions. It summarizes the foundations and limits of what human civilization has learned, identifying for each subdivision of human knowledge its fundamental concepts, principles, mysteries, and misunderstandings. It asserts a

worldview of naturalistic positivism and libertarian capitalism that it predicts will guide future human thought and action.

Outline

0. Prologue

1. **Definition**.
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0.1. Prologue / Definition

This living hypertext is a systematic summary of the knowledge attained by human civilization. For each subdivision of human knowledge, the text identifies its fundamental concepts, principles, mysteries, and misunderstandings.

Status. This draft contains

- a complete section on philosophy;
- a complete section on futurology;
- partially complete sections on logic and physics;
- a complete section on economics;
- some notes and tables on astronomy, biology, political science, linguistics, and history;
- over 1500 internal hypertext links.

A more detailed indication of what parts of the text have been completed is provided by the hypertext links in the Questions Asked section.

0.2. Prologue / Assertions

Positions

This text aims to assert humanity's analyses and theories that are most valid (i.e. convincing and defensible, as opposed to merely logically well-formed). These analyses and theories are not necessarily the most widely-believed or well-known. Potentially contentious assertions are those sympathetic to ontological materialism, epistemological empiricism and positivism, mental functionalism, theological atheism, axiological extropianism, political libertarianism, economic capitalism, constitutional federalism, biological evolutionism, and technological optimism.

Relatively uncontentious assertions appear as normal text. Potentially contentious assertions appear like this. `Denials of widely-held beliefs appear like this.` Questions whose answers lie outside human knowledge appear like this.

Innovations

Almost all of the facts and analyses asserted in this text have of course been asserted before by other humans. Nevertheless, there are some things in this text that the author believes may be novel or at least independently original.

Arrangements. The text places various unoriginal pieces of information into some arrangements that might not have been presented elsewhere before. Among these are

- a list of humanity's most important questions;
- a list of humanity's most important unanswered questions;
- a taxonomy of paranormal phenomena;
- a summary of arguments against the Bible;
- a synopsis of where and how fast Earth is heading in space;
- lists of major biological and historical advances;
- summaries of the platforms of the major American political parties; and
- an extension of the classical Libertarian 2D map of political space.

Analyses. The text gives certain analyses and definitions that, while not wildly original, are nevertheless believed by the author to be improvements on any he had seen before. Among these are

- a definition and taxonomy of living systems;
- a definition of property and the principles of rightful ownership;
- a stipulation of the conditions for the continuity of identity;
- a definition of natural monopoly;
- a self-referential definition of the universe; and
- definitions of existence, time, meaning, consciousness, volition, intelligence, wisdom, and person.

Inventions. The text presents a few notions that may be wholly new. They are

- the idea of memeware;
- the idea that without quantum indeterminacy one could in principle store unlimited amounts of

information within a finite medium;

- the idea that the question "why is there something rather than nothing?" might be answered by a combination of anthropic reasoning and the observation that it is not possible for nothing to be possible.

Predictions. The section on Futurology collects, filters, and refines many predictions by other humans, but also makes predictions that the author has never seen clearly stated by anyone else. They are predictions of

- humanity's three remaining technological revolutions;
- heat pollution as any planet's ultimate limiter of population and development;
- asymptotic limits on the development of economic and military systems;
- limits preventing runaway intelligence and productivity; and
- technology allowing perfect forgery and invasion of physical privacy.

Judgments. The author naturally hopes that the most significant innovation of this text is the judgments it makes and the worldview it synthesizes them into. The text asserts a worldview it calls autocosmology that includes by endorsement the positions of positivism, empiricism, functionalism, atheism, capitalism, federalism, evolutionism, and evolutionary psychology. The text also advances as part of autocosmology some slightly customized versions of other positions. They are

- a materialist ontology that attempts to build from logic to events to causality to existence;
- an extropian axiology that values life and intelligence and the autonomy needed to increase them;
- a libertarian ethics that recognizes all persons' right to life and liberty, and all beings' right not to suffer torture or extinction;
- a libertarian political philosophy that sharply defines the duties, powers, and limits of the state; and
- a futuristic optimism that predicts increasing liberty and prosperity and decreasing ignorance and superstition.

0.3. Prologue / Scope

This text aims to survey the foundations and limits of the knowledge attained by humanity since the dawn of civilization. It does not bother restating what Stone Age humans already knew or what now constitutes common sense and folk wisdom. It does not include operational knowledge about using humanity's technologies or natural faculties. It does not include parochial knowledge about human practices and achievements in art, play, and subsistence. It does not include subjects (such as astrology and psychoanalysis) that do not constitute valid knowledge. It does not simply enumerate facts and ideas alphabetically. It is neither a compendium of trivia nor an almanac of ephemera. It does not attempt to correct or improve the reader's command of any particular human language. It does not try merely to fill the common or embarrassing gaps in people's knowledge. It is not a syllabus of cultural literacy for some particular human society. It is not a guide to understanding but rather a survey of what is to be understood. It does not give demonstrations but rather conclusions. It does not attempt to persuade or teach but rather to assert and inform. It aims to systematically and assertively summarize what humanity does and does not know.

0.4. Prologue / Organization

There are many equally valid ways to organize human knowledge. Knowledge can be organized according to

- the time when it was attained;
- the place where it was attained;
- the techniques with which it was attained;
- the domain to which it applies;
- the purposes for which it is used;
- the names of its topics;
- the thinkers who created it;
- the writings that first recorded it.

This text organizes human knowledge according to the domain to which it applies, and orders these domains roughly from the most universal to the most parochial. This text begins with philosophy, because philosophy addresses the fundamental and ultimate questions about what exists, what we know, and what we value. Philosophy is about the questions that would confront thinkers not only on any world in the universe but on any world in any possible universe. If philosophy is about necessary questions, then mathematics is about necessary answers: the rules of inference and the necessary deductions that all thinkers in all possible universes must acknowledge.

Science is about truth that is not necessary but rather contingent, because it is based on actual observations and inductions about regular or pattern-following phenomena in the universe. The truths of science should be agreed upon by any thinkers in the universe that observe the same regular phenomena. The most interesting known phenomena in the universe are those concerning persons, and so science is divided accordingly. Natural science studies regular phenomena that do not necessarily involve persons and thus are likely to be universal (although many details of terrestrial life science are inevitably parochial). Technology applies mathematics and science toward accomplishing goals. Technological principles are likely to coincide wherever in the universe there are thinkers dealing with similar phenomena and desiring similar goals. Social sciences strive to induce truths that would apply to any kind of person anywhere in the universe, but this is not always possible because humans know of only one kind of person: humans. Most parochial of all would be topics relating to human arts and leisure, which this text excludes as not involving fundamental knowledge.

0.5. Prologue / Questions Asked

These are some of the questions that this text is intended to address. Many of these questions are included because of their importance, while others serve more as invitations to their respective areas of knowledge.

- Philosophy
    - Metaphysics
        - Why is there something rather than nothing?
        - What exists beyond the human senses?
        - What exists after human death?

        - Is the future already decided?
        - What is being?
        - What is time?
        - Does God exist?
        - Which religion is correct?
        - Is the Bible true?
        - What is faith?
        - Which paranormal phenomena are real?
    - Epistemology
        - Might the world be an illusion or dream?
        - What can we know with absolute certainty?
        - What is truth?
        - What is meaning?
        - What is consciousness?
        - What would super-intelligence be like?
        - What are the limits of intelligence?
        - Could a machine think?
        - What is intelligence?
        - What is knowledge?
        - Does free will exist?
        - Does science involve faith?
        - Can science be getting any closer to truth if it is constantly correcting itself?
    - Axiology
        - What is the meaning of life?
        - What do our choices matter if the future is already decided or if all possible worlds exist?
        - What is right and wrong?
        - What is wisdom? What is happiness?
        - Why do evil and misfortune exist? Is the world good or evil? Are humans good or evil?
        - Is blissful illusion better than reality?
        - Can there be an objective rational basis for values?
        - What would an omnipotent omniscience value?
        - What are rights? What entities should have what rights?
        - What is a person? Should any entity have more rights than a person?
        - What should be the rights of children and fetuses? animals and plants? machines?

        - Should private property be allowed?
        - Should private ownership of resources or ideas be allowed?
        - What is justice? liberty? equality? aggression? virtue?
        - What should be the duties and powers of the state?
        - What political system best protects rights and promotes prosperity?
        - What is love? How does one find and recognize it? What if one cannot?
        - How important is it to be liked? How can one be likable? What if one is not liked?
        - How should one face misfortune, fear, and danger?
        - How should one treat one's parents, siblings, spouse, or children?
        - How should one address one's creative and material needs? How should one treat the indigent?
        - How should one handle sex, drugs, and gambling?
        - What is beauty? What is humor?
        - Is beauty subjective or objective?
        - Could non-human intellects have different aesthetic faculties or preferences?
- Mathematics
        - Why does mathematics describe the universe so well?
    - Logic
        - Is "this sentence is false" true or false?
        - What can be proved?
        - What are the limits of logic?
        - If one sand grain is not a heap and adding one grain cannot make a not-heap into a heap, how can any number of grains be a heap?
    - Set Theory
        - What is infinity + infinity? $\infty - \infty$? $\infty \times \infty$? $\infty \div \infty$?
        - What are the unprovable axioms from which mathematics derives?
    - Algebra
        - What is 0/0? What is 0^{-1}? What is 0^0?
        - What is the difference between rational and irrational numbers?
        - What is the difference between real and imaginary numbers?
        - Riemann Hypothesis: are prime numbers really distributed according to the solutions of Riemann's zeta function?
    - Geometry
        - What are the unprovable axioms of Euclidean geometry?
        - Why is a manhole cover round?
        - How many turns does it take for a circle to roll around the circumference of an identical circle?
        - What is the densest way to stack spheres?
        - Poincare Conjecture: is a 4-sphere simply connected (like a 3-sphere) or not (like a

doughnut)?

- Analysis
  - Is 1 equal to 0.99999...?
  - How can a runner reach the finish if beforehand she must get halfway, and before that she must get halfway to halfway, ad infinitum?
- Combinatorics
  - Which is more likely, heads-heads-heads or heads-heads-tails?
  - How can you get a fair (50-50) odds from an unfair (e.g. 60-40) coin?
  - If Monty Hall reveals as empty one of the two prize boxes you didn't pick, should you switch your pick to the other unopened box?
  - How few colors can color the countries of any map?
- Applied Mathematics
  - How is information defined and measured?
  - What is the most basic computing device that is equivalent to any other?
  - What is the fastest possible way to sort a collection?
  - Can a polynomial-time solution for NP-complete problems be found, or proved not to exist?
  - How accurate are opinion polls?
  - What is a standard deviation?

- Natural Science
  -
    - Why does science work so well?
    - What is the origin of the universe?
    - What is the mechanism of the universe?
    - What is the fate of the universe?
    - What is the origin of life?
    - What is the mechanism of life?
    - What is the fate of life?
    - What is the origin of mind?
    - What is the mechanism of mind?
    - What is the fate of mind?
  - Physics
    - Mechanics
      - What is the difference between force, momentum, energy, and power?
      - What is the difference between mass and weight?
      - What is the difference between speed, velocity, and acceleration?
      - Do the conservation of linear and angular momentum entail each other?
      - Why don't humans notice the earth spinning?
      - Why is a moving bicycle easier to balance?

        - How is the sound barrier different from the light barrier?
        - Why is there no sound in space?
        - Why does helium raise the pitch of the human voice?
        - What is the Doppler Effect?
        - Why are solids, liquids, and gases different?
        - How long can a straw be and still work?
        - What is friction?
        - How does a siphon work?
        - Why do helium and hot-air balloons rise?
        - Why are bubbles round?
    - Thermodynamics
        - What is the difference between heat and temperature?
        - Why is there a lowest possible temperature but no highest possible temperature?
        - What is entropy?
        - If not for the Uncertainty Principle, could Maxwell's Demon violate energy conservation?
        - Why does liquid evaporate?
        - Why does liquid condense on cold things?
        - Why does a tile floor feel colder than a carpet at the same temperature?
    - Optics
        - What is light? What is color?
        - What makes primary colors primary?
        - Why are glass and air transparent?
        - Why do mirrors reflect?
        - Why do mirrors reflect left-right but not up-down?
        - Why is the sky blue? Why are sunsets red? Why is blood red? Why are clouds white? Why are plants green?
        - What causes rainbows?
        - What causes mirages?
        - How does depth perception work?
    - Electromagnetics
        - What is electricity?
        - What is magnetism?
        - How are electricity and magnetism related?
        - What stops one solid object from going through another?
        - Why does a magnet attract metal but not wood?
        - Why do parts of magnets repel each other?
        - Why don't birds on power lines get electrocuted?
    - Relativity

- What is Relativity?
- What is space-time?
- What causes gravity?
- How fast does gravitational influence propagate?
- What if the speed of light were infinite?
- What if the speed of light were not constant for all observers?
- What is meant by E=mc2? How is it derived from the postulates of special relativity?
- If a car approached light speed, what would happen to its headlight beams?
- Can anything go faster than light?
- Does light have mass or exert pressure?
- Is time travel possible?
- What are black holes? What are wormholes?
- How do charged black holes interact if photons cannot escape them?
- Why is the vacuum energy density so close to zero and so far from theoretical expectations?
- What is the cosmological constant?
- Why are there 3 dimensions of space and 1 of time?

- Quantum Theory
  - What is a quantum?
  - What is the Uncertainty Principle?
  - How can a particle behave like a wave?
  - What is the smallest particle? What are virtual particles?
  - What is antimatter? Why is antimatter so rare?
  - What is radioactivity?
  - What is the difference between fission and fusion?
  - What is the lifetime of the proton?
  - Do conservation of linear and angular momentum entail each other? What are conservation of parity and pseudovectors?
  - What is gauge symmetry?
  - Is there really supersymmetry between fermions and bosons?
  - Can quark non-confinement and massless strong particles be excluded purely from the Yang-Mills equations of QCD?
  - What property or charge does the weak force act on? Does the weak force attract, repel, or what?
  - Is M theory true?
  - What if radiation were not quantized? What if Planck's constant were a different value? What if there were no quantum indeterminacy?
  - If there were no quantum indeterminacy, couldn't an arbitrarily small space contain an arbitrary amount of information?

- Astronomy
  - Cosmology
    - How did the universe begin?
    - What happened before the beginning of the universe?
    - How will the universe end?
    - Does the universe have an edge?
    - How big is the universe?
    - Where is the center of the universe?
    - What is the universe expanding into?
    - How old is the universe?
    - How do scientists know how old the universe is?
    - Why does the universe's expansion appear to be accelerating?
    - How did galaxies and galaxy clusters emerge from the early smooth universe?
    - What is the universe made of?
    - What is the global topology of the universe?
  - What is the fate of the Earth?
  - How many stars are there? How many visible stars are there?
  - How do scientists know how far away stars are?
  - Why causes spiral galaxies to have arms?
  - Why do stars twinkle?
  - Why do stars appear to the eye to have diameter?
  - What powers the Sun?
  - How cold would it get, and how soon, if the Sun turned off?
  - Why is the night sky dark?
  - Is the dark side of the moon dark?
  - Why does Earth always see the same face of the moon?
  - Why do the planets go the same direction around the Sun?
- Chemistry
  - What is fire?
  - Makes a substance reflective, transparent, or opaquely colored?
  - What is acid?
  - Why does metal rust?
- Geoscience
  - What causes the seasons?
  - Why does a compass point north?
  - What causes earthquakes?
  - What is lightning?
  - What causes wind?

        - Why is the earth's interior hot?
        - What is the difference between true north and magnetic north?
        - What are the Northern Lights?
        - What causes rain?
        - What causes waves and tides?
        - Why are no two snowflakes alike?
        - Why is air thinner at higher altitudes?
        - Why does air temperature change with altitude?
    - Biology
        - What is life?
        - How did life arise?
        - How can the complexity of living things be explained?
        - Is there life and intelligence beyond earth?
        - How improbable was the genesis of life on an earth?
        - How improbable was the evolution of intelligence on earth?
        - How improbable was the evolution of humans on earth?
        - What is DNA?
        - What is evolution?
        - What is a virus? Are viruses alive?
        - How does amino acid sequence determine protein structure?
        - What makes a seed alive or not?
        - Why does food last longer in a refrigerator or freezer?
        - Why don't dry foods spoil?
        - How do drugs work?
        - Why is oxygen poisonous to many kinds of organisms?
        - Why do animals get old and die?
        - Why do animals yawn or sleep?
        - How did sex evolve?
        - How did flight evolve?
        - Why are insects attracted to lights?
        - How do insects walk on water or ceilings?
        - How does memory work?
        - Anthropology
            - Are humans good or evil?
            - How did language evolve?
            - Is humanity still evolving?
            - Are humans naturally meat eaters?
            - Why are humans relatively hairless?
            - Why are there more right-handers than left-handers?

        - Why do males have nipples?
        - Are facial expressions innate or learned?
        - Why are men more promiscuous than women?
        - Why do humans make and enjoy music and humor?
        - Why do human babies cry so much?
- Technology
    - Engineering
        - How does a computer work?
        - How fast and small can computers get?
        - How does a plane fly?
        - How does a satellite stay up in the sky?
        - How does a battery work?
        - How does a refrigerator work?
        - How does a microwave oven work?
        - How does a radio work?
        - How does an antenna work?
        - How does a TV work?
        - How does a light bulb work?
        - How does a camera work?
        - Why does an air conditioner need to be in a window?
        - What are plastic and steel made of?
        - How are diamonds cut?
        - Why do spaceships have to speed up to get to a higher (slower) orbit?
    - Biotechnology
        - What is the difference between a twin and a clone?
        - How are new drugs invented and tested?
    - Management
        - How does one calculate the net present value of a project or investment?
    - Industrial Technology
        - What is the future of telecommunications?
        - What is the future of energy production?
        - What is the future of transportation?
        - What is the future of education?
- Social Science
    - Economics
        - What is wealth? How is wealth created?
        - What is money? What causes inflation? What determines prices?
        - How can productivity, utility, value, and quality be measured?
        - What determines wages and standard of living?

        - What causes recessions and depressions?
        - What determines interest rates?
        - Why are free markets more efficient than controlled economies?
        - What is the social utility of speculation?
        - What are the limitations of free markets?
        - What is a natural monopoly?
        - What is the difference between debt and deficit?
        - Are the rich getting richer and the poor poorer?
        - Does labor-saving technology increase unemployment?
        - Do imports take away domestic jobs?
    - Political Science
        - Why are there corporations?
        - What is discrimination?
        - How unjust is current wealth distribution?
        - Why are criminals freed on technicalities?
        - What is the difference between a liberal and a conservative?
        - What is the difference between a leftist and a rightist?
        - What is the difference between a libertarian and an anarchist?
        - What is the difference between a socialist and a fascist?
    - Sociology
        - Is human population too high?
        - Are human societies naturally warlike?
    - Psychology
        - Why do humans love and hate?
        - Why do humans laugh and smile and cry?
        - Why do humans dream?
        - Why do humans enjoy music?
        - How and why do men and women behave differently?
        - Why do the sun and moon seem bigger when low on the horizon?
    - Linguistics
        - Why are there different languages?
        - What do all languages have in common?
        - Did all languages descend from a common ancestor?
        - Do animals have languages?
        - Is linguistic ability innate?
    - Archaeology
        - How did humans first grow crops?
        - How did humans first domesticate animals?
        - When did humans first control and create fire?

        - When did humans invent the wheel?
        - When did humans first create watercraft?
    - History
        - Why has European civilization been so successful?
        - What have been the most important advances in human history?
        - What caused the fall of the Roman Empire? Mayan Empire? Soviet Union?
        - What caused World War I? The Great Depression? World War II?
    - Futurology
        - Will humanity suffer social decay? economic crash? tyranny? resource depletion? overpopulation? runaway pollution? asteroid impact? nuclear catastrophe? microbial epidemic? nanotech plague?
        - Will humanity enjoy divine salvation or loss of faith? paranormal abilities? alien contact? time travel? warp travel? machine or human superintelligence? immortality?
        - Will it ever be possible to transplant a human mind into a machine?
        - Will it ever be possible to reanimate dead people or frozen brains?

0.6. Prologue / Audience

A summary of the knowledge and ignorance of human civilization could be useful to many.

- Students could use it to gauge how much they have left to learn, and how a given piece of knowledge fits in with all the rest.
- Teachers could use it to show the relationships among the various parts of human knowledge. It could also help them audit how well their course plans cover fundamentals, and help them prepare tests for achievement of basic understanding.
- Colleges could use it as a model report required to be written by graduating students.
- Educated people could use it to help correct any areas of forgetfulness, incompleteness, or obsolescence in their education.
- People building systems of knowledge or opinion could use it as an example of how to address the important and fundamental areas of human knowledge.
- Investigators could use its compilation of mysteries to choose a research area available for important contribution.
- Present-day futurists could consider it as a worldview toward which humanity might be moving.
- Future historians could use it to understand what was known and believed in these times.
- Humans from outside of Western culture could use it to help understand Western thinking.
- Engineers could upload it to help populate the knowledge base for a potential artificial intelligence.
- Archivists could store it to help safeguard human knowledge against catastrophes that might threaten human civilization.
- Persons from outside human civilization -- such as extraterrestrials -- could use it to evaluate the state of human knowledge and ignorance.

- Persons (such as psychics, spiritualists, and alien abductees) allegedly in contact with non-human intelligence could authenticate their claims by answering some of humanity's unanswered questions listed in it.

0.7. Prologue / Copyright

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0.8. Prologue / Authority

No statements should be believed or disbelieved simply because they are offered by a particular text or author. The statements in this text are no exception. They should be judged only by whether they are consistent with evidence, logic, parsimony, and other truth. Even if most of the assertions in this text are valid (i.e. convincing and defensible), that is not strong evidence that none could be invalid.

The number of possible valid human knowledge summaries no longer than this text is immense but finite. This text is certainly far from being the best possible such summary. If the goal of approaching such an optimal summary is worthwhile, then an effective method might be to first produce a suboptimal summary and then to continually correct it or replace it outright with better ones. Thus corrections and replacements of this text are welcome.

At the end of this text is a list of some of the references used in writing it. Because this text attempts to say so much, it contains few references for particular statements. The text tries to explain or justify some of its statements, but most it merely asserts, due to space constraints.

Words in single-quotes are being mentioned rather than used. ('Ten' is a word, while ten is a number.) Words in double-quotes are being used verbatim from some source. Words in italics are being used with emphasis. Words in bold and used at the beginning of a sentence are being defined.

0.9. Prologue / Criticism

Many criticisms of this text are predictable.

- Some will find parts of this compendium uninteresting. The author hopes the text will reawaken their childhood curiosity about the big questions, and tap their adult capacity for marvel at what humanity knows and does not know. Aristotle or Newton would probably each have given his right eye for access to the knowledge that most modern humans choose to ignore.
- Some will note that while the author is known for his sense of humor, there is no humor in this text. The author believes that humor would be inappropriate in what is essentially a reference work. There are probably funny lexicographers, but you wouldn't know it by reading a dictionary.
- Some will say this text has too many definitions and reads like a dictionary. A large part of knowledge is indeed analysis: the carving of nature at the joints.
- Some will say this text has too few definitions, in that it uses too many academic or obscure words. For the sake of brevity, this text indeed takes full advantage of the vocabulary of English.
- Some will regard the text as grandiose or presumptuous. An assertive summary of human knowledge is necessarily grand in scope and must presume to make judgments. However, the reader should not mistake terseness for any claim to authority or certitude.
- Some will not like the way the text organizes and partitions knowledge. There are many useful ways to organize knowledge, but a linear text can only choose one.
- Some will quibble with the relative emphasis the text gives to certain subjects. A text this broad must give incomplete treatment to any topic it covers.
- Some will argue that the text offers few new ideas. The text strives for truth and not mere novelty. Few (if any) of the ideas in this text may be original, but their systematic assertion may be unprecedented.
- Some will consider the text simplistic. As long as it is appropriately categorical and not false or misleading, simplicity will be its virtue and not its vice.
- Some will note that the text does not justify many of its assertions. Indeed, this text necessarily devotes its space to conclusions rather than demonstrations, describing the destination and not the path.
- Some will disagree with the text's assertions. Reality and history will determine which assertions are true and which are not. The truths advanced in this text may not find widespread acknowledgment in the author's lifetime. But as these truths prevail over the third millennium's first century or two, historians will have trouble (as did the author) finding a prior exposition of the emerging worldview that the text identifies and summarizes.
- Some will claim that no valid summary of human knowledge is possible, and that knowledge is subjective to the knower or relative to the context. Such mysticism and cynical relativism can be refuted only by the objective regularity of the universe itself. This objective regularity is the reason why science works.
- Some will question the authority or motivation of the author. Indeed, the qualifications and

intentions of an author should never be exempt from questioning. However, the truth or falsity of each (non-self-referential) statement in the text is nevertheless independent of who wrote it, no matter how hard some might wish otherwise.

- Some will say that this text, so full of second-hand facts and personal judgments, is and will be of no importance. They likely are correct about the text, but not about the worldview it identifies and summarizes.

The most welcome way to criticize this text would be to offer an improved or alternative summary of human knowledge, one just as comprehensive and just as assertive. Even more welcome would be vigorous competition between knowledge-summarizing treatises representing humanity's various contradictory schools of thought. These efforts would in effect "sequence" the most important human memes and their alleles, constituting a sort of Human Memome Project. Such a competition would preserve a fossil record of dying worldviews even as it hastens what the author believes will be the inevitable ascendancy of naturalistic positivism and libertarian capitalism.

0.10. Prologue / Motivation

I began writing this text in order to add to, clarify and preserve what I know and believe. I had never found a single writer with whom I agreed along all the major dimensions of human opinions. But I was surprised I also could not find a single text that systematically summarizes what humanity knows. Encyclopedias are too meek, seeking universal consensus and to alphabetize instead of analyze. Textbooks are too narrow, mapping individual trees and not the forest. Most treatises are too mystical or canonical, substituting intuition or revelation for skeptical rationality. None of them seems to well capture the worldview emerging from the revolutions in physics and biology and from the successes of free markets and free minds. I believe that a worldview of scientific positivism and libertarian capitalism will prevail in human thought and action in the new millennium. Such a future will be good, and I hope to advance it in some small way with this text.

1. Philosophy

Philosophy: the study of ultimate reality and meaning.

1. **Metaphysics**: the study of ultimate reality.
2. **Epistemology**: the study of knowledge.
3. **Axiology**: the study of values.

Necessary Questions

Philosophy asks the questions:

- What is existing?
- What is knowing?
- What is good?

The first two questions face anyone who cares to distinguish the real from the unreal and the true from the false. The third question faces anyone who makes any decisions at all, and even not deciding is itself a decision. Thus all persons practice philosophy whether they know it or not.

Autocosmic Answers

What is existing? Reality consists ultimately of matter and energy and their fundamentally lawlike and unwilled relations in space-time. To exist is to have a causal relationship with the rest of the universe. The universe is the maximal set of circumstancesthat includes this statement and no subset of which is causally unrelated to the remainder. Humans do not know why the universe exists or what it is for. The universe operates without supernatural intervention and according to lawlike regularities that can be understood through empirical investigation and without special intuition. Humans have no credible evidence of any supernatural agency or unity. Humans have no credible evidence that any minds enjoy eternal existence.

What is knowing? Knowledge is justified true belief. Truth is logical and parsimonious consistency with evidence and with other truth. Meaning is the context-sensitive connotation ultimately established by relevant denotation and use. All synthetic propositions (including this one) can only be known from experience and are subject to doubt. A synthetic statement is propositionally meaningless if it is in principle neither falsifiable nor verifiable. A mind is any volitional conscious faculty for perception and cognition. Minds and ideas consist ultimately of matter. Mental states are functional states consisting of causal relations among components for processing information. Consciousness is awareness of self and environment. Intelligence is the ability to make, test, and apply inductions about perceptions of self and world. There are no forms of reasoning or kinds of knowledge that are in principle inaccessible to regular intelligence.

What is good? As autonomous living intellects, we persons value intelligence and life and the autonomy they need to flourish. A person is any intelligent being with significant volitional control over how it affects other beings. All persons have the right to life and liberty. All beings have the right not to suffer torture or extinction. Liberty is volition in the absence of aggression. Aggression consists essentially of 1) coercion or 2) damage to a person's body, property, or rightful resources. Coercion is compulsion of one person by another through force or threat of aggression. Justice is the minimization, reversal and punishment of aggression. The purpose of the state is to effect justice, provide aid and sustenance to persons in mortal danger, protect species in danger of extinction, and prevent torture.

Autocosmology is a synthesis of metaphysical naturalism, ontological materialism, epistemological empiricism and positivism, mental functionalism, theological atheism, axiological extropianism, political libertarianism, economic capitalism, constitutional federalism, biological evolutionism, evolutionary psychology, and technological optimism. Autocosmology is the worldview asserted by this text.

Human Answers

Most humans justify their answers to philosophy's questions using one of four methods.

- **Faith** is belief based on revelation and exempt from doubt.
- **Mysticism** is belief based on private and direct experience of ultimate reality.
- **Skepticism** is belief that is always subject to doubt and justified through objective verification.
- **Cynicism** is the absence of belief.

Faith is the most common mode of belief in the Western world, where the Abrahamic religions are prevalent. Mysticism is the most common mode of belief in the Eastern world. Skepticism is practiced

worldwide (with varying amounts of rigor) by the minority of thinkers who have been influenced more by science than by tradition. Cynicism too is practiced by a worldwide minority, often as a simplistic reaction to the rigidity of faith, the emptiness of mysticism, or the relativism of skepticism.

A skeptic believes what he sees. A mystic believes what he feels. A fideist believes what he hears. A cynic believes nothing. Thus faith fails in not questioning others, and mysticism fails in not questioning the self. Skepticism succeeds by exempting nothing from questioning, while cynicism fails by exempting no answer from disbelief.

Darwin made faith essentially indefensible among Western philosophers. Modern Western philosophy is broadly divided into two traditions, each of which starts with skepticism and takes it to a certain extreme.

- **Analytic** philosophy is popular in English-speaking nations and focuses on logical and linguistic clarification. The Analytic tradition has spawned two major schools:
  - **Logical Positivism** is an analytic school holding that meaningful propositions must be either logically provable or empirically verifiable, and that propositions about metaphysics and ethics are therefore nonsensical or at best emotional.
  - **Ordinary Language Analysis** (or **Oxford philosophy**) is an analytic school holding that the meaning of propositions lies in how their constituent terms are used in ordinary language.
- **Continental** philosophy is popular in France and Germany and attempts to directly confront human existence and ethical freedom without any preconceived notions or categories. The Continental tradition has spawned several major schools:
  - **Phenomenology** is a Continental school emphasizing intuition and raw sensory experience.
  - **Existentialism** is a Continental school emphasizing that the ethical freedom of raw human existence precedes and undermines any attempt to define the essence or nature of humanity.
  - **Deconstructionism** (or **Post-Structuralism**) is a Continental school that questions even the basic notions of objectivity and rationality.
  - **Critical Theory** (or the **Frankfurt School**) is a Continental school that uses Marxist and Hegelian theory to question the social structures underlying traditional rationality.

Analytic philosophy takes skepticism to an extreme by saying that philosophy is only about necessary answers (logic and mathematics) and not necessary questions (metaphysics and axiology). Continental philosophy fails by turning methodological skepticism into mysticism (Phenomenology, Existentialism) and cynical relativism (Deconstructionism, Critical Theory).

1.1. Philosophy / Metaphysics

Metaphysics: the study of ultimate reality.

1. **Ontology**: the study of being.
2. **Theology**: the study of universal being and knowing.

Reality

Reality is everything that exists. Reality consists ultimately of matter and energy and their fundamentally lawlike and unwilled relations in space-time.

Theories of Reality

The primary distinction in theories of reality is between Nature and Spirit.

- **Nature** is the aspects of the universe governed by lawlike and nonvolitional regularity.
- **Spirit** is anything mysteriously volitional or otherwise not governed by lawlike regularity.

Human theories of reality differ primarily according to how they analyze Spirit.

- **Supernaturalism** is the thesis that the fundamental laws of physics make irreducible reference to, or were created by, some agency's volition.
    - **Theism** is the thesis that the universe is affected by supernatural agency.
        - **Polytheism** is the thesis that the universe is affected by supernatural agencies.
        - **Monotheism** is the thesis that the universe is affected by a single supernatural agent, God.
    - **Pantheism** is the thesis that the universe constitutes a supernatural agency.
    - **Deism** is the thesis that a supernatural agency created the universe and lets its laws operate without interference.
- **Naturalism** is the thesis that reality exists and operates without supernatural intervention and according to lawlike regularities that can be understood through empirical investigation and without special intuition.
    - **Atheism** is the thesis that supernatural agency does not exist.
    - **Agnosticism** is the thesis that one does not or cannot know whether supernatural agency exists.

Fideists usually believe in theism or deism.Theism stems from the human propensity to take any mysterious phenomenon as an indication of supernatural intentionality. Primitive humans invented supernatural explanations for:

- the daily cycle of the Sun; the motions of the Moon and planets;
- the seasons; rivers, currents, winds, thunder, lightning, precipitation and drought;
- the genesis, design, and diversity of life; success in farming and hunting;
- the human mind; evil, misfortune, disease, pestilence, war, and death.

However, the Scientific Revolution had established by the middle 1800s that physics, chemistry, astronomy, meteorology, and physiology could be understood in naturalistic terms. Supernatural explanations still seemed necessary for the origin and mechanism of life and mind, and for the origin of the universe itself. In the subsequent century, science outlined the basic answers for these questions, and theism began to be abandoned by serious thinkers. Always hoping that the gaps in scientific knowledge are about to miraculously stop

shrinking, most fideists have retreated into a theism based on an increasingly irrelevant "God of the gaps".

Deists retreat directly to the last trench, and use God only to answer the question of why there is something rather than nothing. Deism is unparsimonious, because it cannot answer the question of why there is God rather than not God.

Mystics usually believe in pantheism or outright idealism. Pantheism and Idealism are incorrect because they too are unparsimonious. They infer spiritual aspects of reality from psychological phenomena that can be explained more parsimoniously in materialist terms.

Skeptics usually believe in naturalism. The varieties of naturalism differ primarily according to their explanation of how matter relates to mind. While naturalists do not know why the universe exists, there is no credible evidence or convincing argument that its existence implies supernatural agency. Parsimony demands that supernatural agency be held not to exist until shown otherwise. Agnosticism constitutes either ignorance of this demand, or a redundant restatement of the principle that synthetic propositions are subject to doubt.

Paranormality

Many humans believe in the existence of phenomena which lie outside the materialist reality of natural science. The phenomena alleged include:

- Beings
  - Ra, Anu, Ashur, Ormazd, Baal, El, Yahweh, Jehovah, God, Zeus, Jupiter, Brahma, Amaterasu, Viracocha, Quetzalcoatl, Great Spirit, Lugh, Pele, Allah, Odin
  - Satan, Lucifer, Beelzebub, Mephistopheles, Loki, Osiris, Shiva
  - souls, spirits, demons, vampires, werewolves, hobgoblins, bogeymen
  - Santa Claus, Easter Bunny, Tooth Fairy
  - angels, fairies, leprechauns, gnomes, elves
- Places or States
  - Heaven, Elysium, Olympus, Asgard, K'un-lun, T'ien
  - Hades, Tartarus, Orcus, Acheron, Hell, Gehenna, Jahannam, bhumis, Jigoku
  - Sheol, Styx, Purgatory, Valhalla, Limbo
  - nirvana, buddhata, satori
- Forces or Substances
  - Good, Spirit, atman, ch'i, prana, karma, life force, Godhead, Nous
  - Evil, Thanatos
  - ether, humours, ectoplasm, elan vital, phlogiston, polywater
  - antigravity, cold fusion, perpetual motion, free energy, orgone
- Apparitions
  - auras, bio-energy, chakras, Kirlian photography
  - ghosts, reincarnation, samsara

    - miracles, stigmata, speaking in tongues, possession, spontaneous human combustion
    - UFOs, alien abductions, crop circles, Bermuda Triangle
- Powers
    - voodoo, witchcraft, sorcery, magick, shamanism, wicca
    - telekinesis, astral projection
    - crystals, pyramids
    - faith healing, alchemy, homeopathy, acupuncture, chiropractic
- Knowledge
    - astrology, tarot, palmistry, numerology, phrenology, enneagrams, dowsing
    - I Ching, feng shui
    - prophecy, fortune-telling, Nostradamus, Bible codes
- Perception
    - clairvoyance, telepathy, channeling

Humans have no credible evidence for these phenomena. Over time these phenomena will recognized as delusions, hysteria, myths, nonsense, and hoaxes.

1.1.1. Philosophy / Metaphysics / Ontology

Ontology: the study of being.

Understanding of reality and existence is built up according to experience from elements provided by logic: terms, their properties and relations, and the attributions and inferences that can be made among them. From these can be derived the ontological notions of causality, existence, time, identity, and space.

Causality

A **circumstance** is a set of terms and their fixed properties and relations that as a whole can be distinguished from other such sets and identified with itself. A **change** is a relation between an ordered pair of distinguishable circumstances and is defined by the two circumstances that it relates. An **effect** is a change that can be attributed. A **cause** is that to which an effect can be attributed in whole or in part. An **influence** is that to which an effect can be only partly attributed. Attribution is a fundamental concept that underlies the notions of both ontological causality and logical properties.

A **necessary** cause is one which can be inferred from the effect. A **sufficient** cause is one from which the corresponding effect can be inferred. To **determine** is to be the necessary and sufficient cause for. **Possibility** is the property of not being contradicted by any inference. **Logical possibility** is the property of not contradicting the laws of logic. **Physical possibility** is the property of not contradicting the laws of nature.

Is causality an illusion? Does every effect have a cause, or do some effects have no cause? Can there be a cycle of causality, in which an effect both precedes and contributes to its cause? Can one know the answers to these questions?

Existence

The **universe** is the maximal set of circumstances that includes this statement and no subset of which is causally unrelated to the remainder. To **exist** is to have a causal relationship with the rest of the universe. An **entity** is any term that exists. Two circumstances are causally unrelated if neither could ever influence the other.

It is unparsimonious to say other universes exist. One could imagine a set of circumstances causally unrelated to the maximal set that includes this sentence, and could choose to consider it a separate universe. But to say those imagined circumstances "exist" is to cheapen existence from causal reality to mere imaginability. An imagining does not establish the existence of the thing imagined.

Why is there something rather than nothing? Is there an objective purpose for that which exists? How could one recognize an answer to these questions? Are these questions meaningless?

Humans do not know why there is something rather than nothing, or if the question is even meaningful. If this question has a parsimonious answer, it must consist in a self-explaining fact or cycle of facts. A candidate for such a fact would be the concept of God in the Ontological Proof, but that proof is not convincing. Humans do not know any such fact(s), or even if they could possibly exist. If it is asserted that non-existence is more likely or natural than existence, one could ask why this asserted tendency (toward non-existence) *itself* exists.

A possibly meaningful (but unparsimonious) answer to the Ultimate Why is that the universe exists (more precisely, is perceived to exist) roughly because it is possible. The reasoning would be as follows. Absolute impossibility -- the state of affairs in which nothing is possible -- is itself not possible, because if nothing truly were possible, then absolute impossibility would not be possible, implying that at least something must be possible. But if at least one thing is possible, then it seems the universe we perceive should be no less possible than anything else. Now, assuming that physicalism is right and that qualia and consciousness are epiphenomena, then the phenomenology of a mind and its perfect simulation are identical. So whether the universe we perceive existed or not, it as a merely possible universe would be perceived by its merely possible inhabitants no differently than our actual universe is perceived by its actual inhabitants. By analogy, the thoughts and perceptions of a particular artificial intelligence in a simulated universe would be the same across identical "runs" of the simulation, regardless of whether we bothered to initiate such a "run" once, twice -- or never.

Thus, the universe might merely be the undreamed possible dream of no particular dreamer.

Time

An **event** is a change that cannot interestingly be subdivided into constituent changes. **Time** is the ordering of events according to the potential of some events to causally influence other events. If (as in this universe) causal influence propagates through space only at finite speed, then some events can be far enough apart in space as to be in principle unable to influence each other. In this case time is a partial order on events instead of a total order.

An **instant** is a point on a linear continuum onto which events have been associated in a particular reference frame according to their order in time. **Duration** is a measure of the separation between two instants in time determined by counting intervening events of the kind

that recur in proportional numbers to each other. Examples of such events are the swings of a pendulum or the vibrations of an atom.

Eternity is an entire linear continuum of instants. Thus by definition there is between any two instants another instant. However, it is not necessary that between any two events there is another event. Nor is it necessary that there be a first event, even if the past is of finite duration. Just as there is no smallest positive real number, there might be no first event, because there might be no event associated with a first instant (t=0). Instants are mathematical constructs that do not always have an associated actual event.

The **future** is, from the perspective of a particular event, the set of all events that the event potentially influences. The **past** is, from the perspective of a particular event, the set of all events by which the event is potentially influenced. The **present** is, from the perspective of a particular event, the set of all events simultaneous with it. **Simultaneity** is a relation enjoyed by two events if and only if they share identical sets of past and future events.

Hypertime. Time is often said to pass or flow or to be moved through. This metaphor of motion is misleading, because motion is spatial displacement over time, measured for example in meters per second. But a 'motion of time' measured in seconds per second is nonsensical, and so temporal displacement 'over time' requires a notion of hypertime, measured in seconds per hyper-second. This is no help, because hypertime too will be said to flow -- through hyper-hypertime. There is no reason to posit an absolute or universal or extra-temporal or distinguished present that flows or passes or marches and continuously turns absolutely future events into absolutely past ones. Past, present, and future are relations with a particular event and are not absolute properties in themselves.

Changing the future. The present can affect a future event, but it cannot "change" a future event. An event is itself a change and time is no more than an ordering of these changes. If changes themselves can change, these hyper-changes are hyper-events that can be ordered into hypertime. Events cannot change over time because events are defined by their pre- and post-conditions. To talk of different post-conditions for an event is really to talk of a different event, just as to talk of different cardinality for a number is really to talk of a different number. This does not imply determinism, because determinism is a statement about inference and not about inevitability.

Determinism is the thesis that a sufficient knowledge of any particular set of circumstances could be used to completely infer any subsequent circumstance. Some humans take determinism to be the thesis that the future is already decided, that the present was always going to be the way it is, that statements about probability and possibility are merely statements about one's incomplete knowledge, and that only actual possibility is that which is already inevitable.

Such a notion of ontological determinism is different from epistemic determinism only if there is a hypertime in which different points of normal time can "already" coexist. A notion of ontological

determinism that is strictly different from epistemic determinism can have no practical consequences. As a difference that makes no difference, ontological determinism is a thesis that parsimony demands be rejected. Adopting the thesis makes as much sense as adopting the thesis that the universe is five minutes old. It is inconsequential -- and thus meaningless -- to say the future is already decided.

Some humans argue that if determinism is true, then no argument is to be considered valid as it is simply a train of statements following a predestined track. First, this misconceived argument applies as well to itself as it does to any other argument. Second, even in a deterministic system there can arise processes that tend to produce certain results. If viable organisms can arise, reproduce, and evolve due to natural selection in a deterministic universe, then surely viable arguments can arise, reproduce, and evolve due to competition in a marketplace of ideas. The viability of an idea or argument is closely related to its epistemological validity, and so the opposite misconception could occur: an argument might be considered *more* valid merely because it is at the end of so many predestined tracks.

Time Travel. Time travel would imply the existence of either hypertime or circular causality. Humans have no reason to think either exists.

Temporal Anisotropy. In a short video clip showing two billiard balls bouncing off each other, forward and backward in time are indistinguishable if one ignores friction and inelasticity. In a longer video of a billiards break, the future is the end in which the balls are no longer in a nicely ordered triangle. If causes can be attributed to effects as easily as effects can be attributed to causes, then causal laws do not distinguish past and future, and the future for an event is the direction of increasing disorder in the system. Traces and memories of the past are a localized increase in order at the expense of an increase in system-wide disorder. Due to statistical considerations, some systems can cycle between order and disorder. In such systems the direction locally considered to be future can vary over the timeline of the system.

Temporal anisotropy is not determined by the expansion of the universe, nor by the direction of electromagnetic radiation. For electromagnetism, the attribution of influence works equally well in both time directions. There is no inherent difference between the absorption and emission of a photon. Boundary conditions are logically possible in which photons are set in motion without having been emitted from anything, and which converge in shrinking spheres on an anti-emitter.

Identity

Identity is the relation that obtains between two entities (or terms) that are the same instance, i.e., that could never be counted as two. Leibniz's Principle of the Identity of Indiscernibles states that if there is no possible way to distinguish two entities then they really are the same entity.

A given entity is identified through time with its closest close-enough continuous-enough continuer. A **continuer** is an entity which is similar to a previous entity and exists because of

it. A continuer is close enough if it retains enough of the original entity's properties. A continuer is closest if it retains more of the original entity's properties than any other continuer. A continuer is continuous enough if there is no extraordinary discontinuity in its relationship to the original entity.

Space

Space is the seemingly boundless and continuous three-dimensional extent in which all matter is located and all events occur. It seems logically possible that space could be not only boundless (like the surface of a sphere) but infinite (like an infinite plane). It even seems logically possible that space could be locally discontinuous.

Do space and time have absolute existence independent of their contents? Or are they simply a system of relations among entities and events? Is there a way to answer these questions, or would any answer not make a difference?

1.1.2. Philosophy / Metaphysics / Theology

Theology: the study of universal being and knowing.

God

God is supernatural agency or unity, often considered necessary, perfect, timeless, omniscient, omnipotent, benevolent, and personal. A **deity** is a supernatural person, usually considered immortal, that demands or deserves human worship or reverence and that wields supernatural influence over human affairs.**Divinity** is the property of being supernatural and sacred. **Sacredness** is the property of being worthy of reverence or worship.

Humans have no credible evidence or convincing proof of any deities, including a God, Creator, First Cause, Perfect or Necessary Being.

Humans have proposed philosophical proofs of God as an alternative or supplement to historical revelation of God's existence.

- **Ontological Proof**. God is the most perfect idea. If God did not exist, then the idea of god would be imperfect in its existence, and would not be the most perfect idea.
- **Cosmological Proof**. All effects must have a cause, and an infinite regress of causes is impossible. Therefore, God is the First Cause.
- **Teleological Proof**. The universe (or its set of physical parameters) is evidently designed, and therefore must have a Designer.
- **Anthropological Proof**. Humans have a universal sense of morality and spirituality, and the cause of this effect is God.
- **Mystical Proof**. God can be experienced directly.
- **Pascal's Wager**. Blaise Pascal argued that it is a safer bet to incorrectly believe in God than to incorrectly disbelieve in God.

None of the proofs of God is generally accepted as convincing, due to various counter-arguments.

- The Ontological proof assumes without evidence that ideas can exist independently of minds, or that universals can exist independently of instances, or in general that logical necessity is the same thing as ontological necessity.

- The Cosmological proof is unparsimonious. If God can be self-caused, then so can the universe. Also, an infinite regress of causes is as logically possible as an infinite progress of effects.
- The Teleological proof is undermined by unrelenting progress in reducing the number of those initial parameters and by anthropic arguments for why they should allow the development of life and intelligence.
- The Anthropological proof is undermined by other, more plausible naturalistic explanations for the origin of human nature.
- The Mystical proof is undermined by other, more plausible naturalistic explanations of mystical experiences.
- Pascal's Wager provides no method for choosing among conflicting actual and possible religions, and invites one to follow false hope and blind fear rather than clear reason. Some religions might offer some hopes (e.g. that good behavior will be reciprocated) that may in fact be justified (even if on grounds other than those the religion offers). But the primary hopes offered by all major religions -- of afterlife, or communion with a consequential ultimate reality -- are false.

Many humans claim to have evidence of revelation from their god(s). Any god could trivially inscribe or authenticate its revealed message through supernatural patterns (in cosmological or quantum phenomena) or ongoing miracles (such as prophecy or communication with a spirit world). There is no credible evidence that any such revelation has been competently attempted by any god(s).

Afterlife

Most humans believe that some form of reincarnation or immortality awaits them after death. Humans have no credible evidence of reincarnation or any kind of afterlife.

Faith

Faith is belief based on revelation and exempt from doubt. Skepticism involves zero faith because it holds not even a single belief that is based on revelation and exempt from doubt. Skepticism holds that truth is not simply revealed but instead must always be subject to doubt, demonstration, and rederivation. This belief about truth is *itself* neither revealed nor exempt from doubt, but is instead subject to continual test.

It is possible (but unlikely) that this epistemological belief could one day stop yielding satisfactory results. For example, if God appeared and started violating physical laws, predicting the future, punishing infidels, and rewarding believers, then faith would suddenly be more satisfactory than skepticism. Until such a development, skepticism continues to be more satisfactory than faith.

Faith is not simply an absence of doubt, because tautologies are beyond doubt and yet are recognized not revealed. Faith is not simply any confident reliance on authority, because an authority can be relied upon even confidently without being held exempt from all doubt. Faith is not simply any provisional hypothesis believed without complete evidence, because a proposition can be provisionally

believed without being held exempt from all doubt. Faith is not simply any affirmation of values, because to affirm a value is not to posit a proposition but to make a valuation. Faith is belief based on revelation and exempt from doubt. Fideists often say skeptics too have "faith" in science or reason, but this corrupts the definition of 'faith'. Faith must be embarrassing if its only defense is the claim that everybody is guilty of it.

Origin of faith. Humans' propensity for faith derives perhaps from their dependence on teaching by parents and society. In the absence of a biological mechanism for offspring to inherit knowledge directly, a predisposition for unquestioning belief in authority might help spare each generation from having to rediscover or verify everything.

Mysticism

Mysticism is belief base on private and direct experience of ultimate reality. Mysticism holds that belief can be justified simply by the intensity or directness of an experience, and without a showing that the experience has any objective basis or consequences.

Rejecting objectivity and the distinction between the experiencer and the experienced, mysticism thus mistakes feeling for knowing. Mystics are forever free to claim that anyone who doesn't feel what they feel is somehow "doing it wrong". The conclusions of mysticism are usually unfalsifiable or inconsequential and thus propositionally meaningless.

Some mystics compare meditation to advanced mathematics and claim that both yield conclusions that can only be verified by adept practitioners. This claim is misleading. It is true that creating and even comprehending advanced mathematical conclusions usually requires specialized training. But all mathematical demonstration is by definition subject to verification through mechanical symbol manipulation. This symbol manipulation is not necessarily private or "interior" like the experience of a mystic, but is expressly public and exterior.

Origin of mysticism. Humans' propensity for mysticism derives perhaps from their nature as intelligent social animals who survive by detecting patterns and especially intentions in an environment dominated by their social interactions. Humans appear biased to see intentionality not only in friends, foes, predators, and prey, but also in weather, the heavens, or the universe itself. This bias is perhaps related to the general human tendency (known in psychology as the Fundamental Attribution Error) to incorrectly emphasize intentional explanations over situational or circumstantial ones.

Religion

Religion is any system of belief based on faith or mysticism, or involving worship of or reverence for some deity.

Science and Religion. A common misconception is that science might be an alternative to religion for answering questions about meaning and value. Those questions are the domain of philosophy, whereas science deals with objective phenomena. Science depends on the epistemological principle of skepticism, and any "conflict" between science and religion is really a conflict between skepticism and

faith (or mysticism). Religion can be made superficially compatible with science by restricting itself to questions that are a) scientific but unanswered or b) philosophical. However, faith- or mysticism-based religion can *never* be compatible with the skepticism on which science -- and all epistemologically valid philosophy -- is built.

Belief Systems

Most humans attempt to understand the world through faith or mysticism. Of the major groups of believers, only agnostics and atheists avoid both faith and mysticism. This table summarizes the major human belief systems. Statistics on adherents are assembled from various sources, including Encyclopedia Britannica and adherents.com. The 'Deity' column identifies each system's type of supernaturalism , except that for monotheisms it instead names the deity. The 'Fate' column tells what each system believes happens to a person after death.

- *death*: personality ceases at death.
- *judged*: the quality of an eternal afterlife is determined by a judgment of one's mortal behavior.
- *rebirth*: personality is after death recycled into a new organism, usually according to one's mortal behavior and with a loss of memory, and sometimes with the possibility that with good enough behavior or insight the cycle can be broken into communion.
- *commun*: personality ascends after death to a higher plane of (perhaps non-personal) communion with the universe.
- *immort*: personality graduates after death to (usually disembodied but conscious) immortality.

Belief System	Millions	%	Where	When	Founder	Scripture	Deity	Fate
Christianity	1960	34%	West	c30	Jesus	New Testament	God	judged
Roman Catholicism	981	17%		c30	Paul, Peter			
Protestantism	404	7%						
Baptist	100	2%		c1611	Thomas Helwys			
Lutheran	76			1517	Martin Luther	(95 Theses)		
Anglican	70		England	1534	Henry VIII			
Episcopalian	3		USA	1789				
Methodist	50			1738	John Wesley			
Reformed				1536	John Calvin	(Institutes...)		
Presbyterian								
Pentecostal	9		USA	c1880	Charles Parham			
Church of Christ	1.6		USA	c1832	Campbell, Stone			
Society of Friends			USA	1650	George Fox			
Eastern Orthodox	123	4%		1054	Michael Cerularius			
Mormonism	11		Utah	1831	Joseph Smith	Book of Mormon		
Jehovah's Witness	1.4 US		USA	1878	Charles Russell			
Christian Science	0.4		USA	1879	Mary Eddy	(Science & Health)		

Islam	1130	19%	Mideast	600	Muhammad	Koran	Allah	judged
Sunni		16%						
Shiite		3%						
Sufism								
(Agnosticisms)	887	15%					non	death
Hinduism	793	14%	India	1000 BCE	(Aryans)	Vedas, esp. Upanishads	poly	rebirth
Hare Krishna								
Buddhism	325	5.6%	E. Asia	525 BCE	Buddha	Tipitaka	pan	rebirth
Zen Buddhism								
Amidism								
(Atheism)	222	3.8%					anti	death
Chinese folk religions	221	3.8%	China					
Confucianism			China	500 BCE	Confucius	Analects; I Ching	non	death
Taoism			China	550 BCE	Lao Tzu	Tao-Te-Ching	poly	immort
Asian New Religions	106	1.8%						
Animisms	103	1.8%						
Shamanism								
Voodoo								
Sikhism	19	0.3%	Punjab	1604	Guru Nanak	Adi Granth	Sat-Kartar	rebirth
Judaism	14	0.2%	Israel	1800 BCE	Abraham	Old Testament	Yahweh	death
Spiritism	10							
Bahaism	6		Persia	1863	Baha Ullah	Kitabi Ikan	Allah?	
Jainism	5		India	550 BCE	Mahavira	Purvas et al.	pan	rebirth
Shintoism	3		Japan	<500	(Japanese)		poly	commun
Cao Dai	3		Vietnam	1919	Ngo Van Chieu		God?	rebirth
Tenrikyo	2.4		Japan					
Scientology	1		USA	1954	L. Ron Hubbard	Dianetics	(aliens)	immort
Unitarianism	0.8							
Rastafarianism	0.7							
Zoroastrianism	0.2		Persia	1000 BCE	Zarathustra	Avesta	Ahura Mazda	judged
Parsee	0.19							
Mandaeanism	0.045		Iraq	c300		Haran Gawaita	mono?	immort
Other	1.9							
Eckankar			USA	1965	Paul Twitchell		God	immort
Heaven's Gate			USA	1971	Marshall Applewhite		(aliens)	immort
Mithraism			Persia					
Raelianism			France	1973	Rael	True Face of God	(aliens)	
Rosicrucianism			West	1614	Johan Andrea	Confessio rosae crucis		
Santeria			Cuba					

Satanism								

Fideisms

Judaism is the Semitic monotheistic fideist religion based on the *Old Testament*'s (1000-600 BCE) rules for the worship of Yahweh by his chosen people, the children of Abraham's son Isaac (c1800 BCE).

Zoroastrianism is the Persian monotheistic fideist religion founded by Zarathustra (c628-c551 BCE) and which teaches that good must be chosen over evil in order to achieve salvation.

Christianity is the West Eurasian monotheistic fideist religion professing that Jesus of Nazareth (c6 BCE - c30 AD) is the descendent of Abraham and the Son of God whose sacrifice for humanity's sins was recorded in the *New Testament* (c100), and who fulfilled the prophecies of the divinely inspired *Old Testament*.

Islam is the Middle Eastern monotheistic fideist religion professing surrender to the will of Allah (God), whose revelations in the *Old* and *New Testaments* were superseded by the *Koran* revealed to Muhammad (c570 - 632-06) for his chosen people, the children of Abraham's son Ishmael (c1800 BCE).

Sikhism is the Punjab monotheistic fideist religion founded by Guru Nanak (1469-1539) and whose sacred *Adi Granth* (1604) overlays a spartan righteousness onto Hindu cyclical cosmology.

These religions place unwarranted faith in purported revelations for which there is no credible evidence of authenticity or validity.

Mysticisms

Hinduism is the South Asian polytheistic mystical religion based on the *Veda* scriptures (c1000 BCE) and professing a cyclical cosmology, an ultimate reality called brahman, gods Vishnu and Shiva, and reincarnation of atman (soul) under the influence of karma.

Taoism is the Chinese polytheistic mystical religion based on the *Tao-Te-Ching* ascribed to Lao Tzu (c550 BCE) and which advocates a path (tao) of minimalist serenity and reverence for various deities.

Shintoism is the Japanese polytheistic mystical religion involving mainly the observance of customs and festivals honoring various deities.

Jainism is the Indian pantheist mystical religion founded by Mahavira (599-527 BCE) and which blends monastic asceticism with Buddhist cyclical cosmology.

Buddhism is the East Asian pantheist mystical religion founded in India c525 BCE by the Buddha, who taught that existence is cyclical suffering caused by desiring and can be overcome by the "eightfold path" of right thought and deed.

Confucianism is the Chinese nontheistic mystical religion based on the sayings of Confucius (c500 BCE) recorded in the *Analects*, and which teaches social order, scholarship, filial reverence for family and ancestors, and divination.

These religions posit entities (such as gods or spirits or forces) to explain subjective mystical experiences which have simpler naturalistic explanations. These religions allege phenomena (such as rebirth and divination) for which there is no credible evidence.

Evidence For Christianity

Since Christianity is the most prevalent belief system among humans, it deserves special attention. The best evidence for the Christian doctrine of a divine Jesus is:

- Epistles c.50-60CE
  - Paul's letters broadly confirm the teachings and miracles of Jesus, and specifically his resurrection [1 Cor 15].
- Gospels c.60-90CE
  - The veracity of the gospel accounts is supported by their mutual aggreement and their inclusion of embarrassing and vivid details.
  - The gospels are unanimously persuasive that Jesus died, and report many vivid accounts of encounters with the risen Jesus.
  - The gospels describe in vivid detail Jesus' miracles (many healings, three reanimations, etc.) and their acceptance throughout Judea and Galilee.
- Extra-biblical evidence
  - The 1st-century Jewish historian Josephus confirms the historicity of Jesus by mentioning him as the brother of the martyred James.
  - Non-Christian writers like Josephus and Celsus agree that Jesus was known for his "feats" and "wonders".
  - Christianity as a movement survived even in Palestine among the people who would have had the best available opportunity for refuting its claims.

Arguments Against Christianity

The main reasons not to believe the Christian doctrine of a divine Jesus are:

- the alternative naturalistic explanations of the existing evidence;
- the missing evidence needed to prove such divinity;
- the implausibility of such divine activity; and
- the cascading implications of accepting such evidence.

In addition, the Christian gospels themselves are suspect because of their sources, contradictions, and apologetics.

Naturalistic explanations. Jesus of Nazareth was a faith healer and self-proclaimed divine savior who tried to reform his native Jewish religion. However, the evidence about Jesus is less likely to have resulted from divinity than from misinterpretation, exaggeration, rationalization, delusion, deception, and mythologizing. Indeed, perhaps the greatest weakness of the claims for Jesus' divinity is the gospels' reliance on and vouching for the Old Testament, a patchwork of folklore, legends and myths about a tribe whose

patriarch Abraham turned to monotheism because of fertility problems. Jesus was a Jewish prophet who affirmed Jewish law [Mt 5:17-18; Lk 2:27,39; Jn 10:35], observed the Jewish calendar [Lk 4:16, Mt 24:20], and preached in Jewish synagogues [Mk 1:21, 1:39, 6:2; Mt 4:23, 9:35, 13:54; Lk 4:15, 4:44, 6:6, 13:10, 19:47; Jn 6:59, 18:20] exclusively to Jews [Mt 10:5, Mt 15:24] about the God of Israel [e.g. Mk 12:29]

Miracles. In the gospels Jesus heals the sick (blindness, skin disorder, bleeding, fever, paralysis, withered hand), revives the recently deceased, calms a storm, multiplies food, and walks on water. The miracles ascribed to Jesus seem not to have been very convincing [Mt 11:20, Lk 10:13, Jn 6:66, 10:32, 12:37, 15:24], and seem explainable by a combination of conventional faith healing, exaggeration, and mythologizing. The three people Jesus allegedly reanimates [Mk 5/Lk 8; Lk 7; Jn 11] might not actually have been clinically dead, and the gospels report not a single indication supporting such a diagnosis. Any cases of blindness, paralysis, or demonic possession cured by Jesus could have been psychogenic. The one case of congenital blindness is recorded as disputed, and only in the latest gospel [Jn 9].

God? The Christian doctrine of the "trinity", attempting to reconcile Jewish monotheism with Jesus' self-revelation, holds that Jesus 1) is both fully human and fully divine, and 2) is God (in a different "person"). The former is a contradiction, and the latter has no scriptural basis. In the gospels Jesus never claims identity with God or even explicit divinity, but rather a divinely special status as "the Son of God" and the "Anointed One" (Hebrew: messiah; Greek: christos). Jesus repeatedly distinguishes himself from God:

- Why do you call me good? No one is good--except God alone. [Mk 10:18, Lk 18:17]
- No one knows about that day or hour, not even the angels in heaven, nor the Son, but only the Father. [Mk 13:32]
- And everyone who speaks a word against the Son of Man will be forgiven, but anyone who blasphemes against the Holy Spirit will not be forgiven. [Lk 12:10]
- Father, if you are willing, take this cup from me; yet not my will, but yours be done. [Lk 22:42-43]
- Father, into your hands I commit my spirit. [Lk 23:46]
- the Father judges no one, but has entrusted all judgment to the Son [Jn 5:22]
- By myself I can do nothing; I judge only as I hear, and my judgment is just, for I seek not to please myself but him who sent me. [Jn 5:30]
- I do nothing on my own but speak just what the Father has taught me. [Jn 8:28]
- I came from God and now am here. I have not come on my own; but

he sent me. [Jn 8:42]

- If I glorify myself, my glory is nothing; it is my Father who is glorifying me, of whom ye say that He is your God. [Jn 8:54]
- I did not speak of my own accord, but the Father who sent me commanded me what to say and how to say it. [Jn 12:49]
- The words I say to you are not just my own. Rather, it is the Father, living in me, who is doing his work [Jn 14:10]
- If you loved me, you would be glad that I am going to the Father, for the Father is greater than I. [Jn 14:28]
- 'I am returning to my Father and your Father, to my God and your God. [Jn 20:17]
- As the Father has sent me, I am sending you. [Jn 20:21]

When Jesus' opponents say his assumption of authority could be interpreted as a claim of divinity, all three synoptics agree [Mk 2:10, Mt 9:6, Lk 5:24] that Jesus merely asserted "authority on earth", and none intimates that his accusers concluded he was affirming their accusation. In the one instance in the gospels [Jn 10:33ff] in which Jesus' identity with God is explicitly discussed, Jesus cites a Psalm [82:6] as a precedent for his metaphor, and hastily retreats to his formulation of being "God's Son", adding vaguely that "the Father is in me, and I in the Father" (which 1 Jn 2:15 says is true of anyone who acknowledges that Jesus is the Son of God). When at another time [Jn 5:18ff] the Jews characterized the "Son of Man" title as "making himself equal with God", Jesus answered not by claiming identity but by drawing distinctions:

- the Son can do nothing by himself
- the Father loves the Son
- the Father judges no one, but has entrusted all judgment to the Son
- the Father sent the Son
- the Father has granted the Son to have life in him
- the Father has given him authority to judge
- I seek not to please myself but him who sent me

Thus Jesus retreats the only two times he is accused of claiming identity or equality with God. In the Passion story, Jesus was mocked or accused as a faith healer, prophet, king of the Jews, Messiah, and "Son of God" [Jn 19:7] -- but never as divine or as a god. When Jesus died, onlookers are said to have exclaimed not that Jesus was God, but rather the "Son of God" [Mat 27:54].

The title of 'God' is never reliably applied to Jesus anywhere in the New Testament. (In many translations of 2 Pet 1:1 and Titus 2:13, the description "God and Saviour" is seemingly applied to Jesus, but the scholarly consensus regards these two letters as late and pseudoepigraphic.) Acts quotes [2:22, 2:36, 3:13, 10:38, 17:31] Peter

and Paul describing Jesus in terms of a man appointed to an office, but never calling him God. The gospel authors never explicitly claim Jesus to be God, and the closest they come is the vague language of Jn 1: "the Word was God" and "became flesh". John quotes Thomas exclaiming [Jn 20] "my Lord and my God", but immediately states [20:31] as a creed merely "that Jesus is the Christ, the Son of God". The "mystery" of Jesus' nature was hardly clarified by the Apostles [e.g. Phil 2:6, Rom 1:4, Col 1:15, Col 2:9], whose epistles never claim Jesus has any kind of identity with God. (Christian scribes tried to change that; cf. the differing manuscripts for Rom 9:5, Acts 20:28, and 1 Tim 3:16.)

Thus, just as Jesus failed to leave clear teachings about salvation, hell, divorce, circumcision, and diet, he also did not effect a competent revelation of who precisely he was. Depending on e.g. various 4th-century Roman emperors, there waxed and waned such christological heresies as Ebionism, Docetism, Adoptionism, Dynamic Monarchianism, Sabellianism, Arianism, Marcionism, Apollonarianism, Nestorianism, Monophysitism, and Monothelitism. The doublethink of the "trinity" is not found in the Bible, but instead was invented to reconcile Jewish monotheism with Jesus' idiosyncratic Sonship claims.

"Son of God". Jesus seems to have been illegitmate, and to have been known to be such in his community [Mt 1:18-24, Jn 8:41]. His only recorded words before his ministry concern his disobedience [Lk 2:48,51] at age 12 to his mother and stepfather, whom he denied [cf. Mt 23:9] by calling the Temple "my Father's house". He spurned his stepfather's trade of carpentry to take up a ministry proclaiming himself the son not of Joseph but of God. Despite alleged angelic revelations [Lk 1:32, Mt 1:20, Mt 2:13, Mt 2:20] to Mary and Joseph, they (and Jesus' siblings) did not believe in him [Jn 7:5, Mt 13:57] and thought him "out of his mind" [Mk 3:21], leading Jesus to repeatedly stress [Mk 3:33, 10:29; Mt 10:37, 12:48, 19:29; Lk 11:27-28, 14:26] that one should choose God over one's biological family. Only on the day of his death do the gospels record a single friendly word [Jn 19:26] from Jesus to his family.

Delusional Schizophrenic? Jesus began his (apparently one-year) ministry as a follower of John the Baptist (whose embarrassing baptism of Jesus is played down or not mentioned in the later gospels). In the earliest gospel (Mark), Jesus never calls himself Christ/Messiah, is reluctant for his special nature to be known, and (as he does in Matthew) despairs on the cross. (By contrast, in the later Luke and John, Jesus asserts he is Christ, and confidently assures a co-crucified convict of their impending ascension.) Jesus "could not do many miracles" in his hometown [Mk 6:5, Mt 13:58, Lk 4:24], and he at times was considered mad by other Jews [Jn 10:20]. Jesus' ministry seems not to have been joined by a single family member or prior acquaintance, but only by strangers. Jesus satisifed the diagnostic criteria of paranoid schizophrenia:

- hallucinations: hearing or seeing God, Satan, demons, and angels;
- deslusions of grandiosity: belief that he is the salvific Christ/Messiah with miraculous powers and apocalyptic foreknowledge;
- delusions of persecution: temptation by Satan; opposition by demons;
- an insidious reduction in external relations and interests: nomadic asceticism; estrangement from his family.

However, Jesus was not so mentally ill as to believe he was omnipotent. The gospels say repeatedly [Jn 7:1, 8:59, 11:53-54, 12:36; Mt 12:14-15, Mk 3:6-7, Lk 13:31,33] that Jesus retreated from or avoided danger. He was secretive and evasive about his special nature [Mk 3:12, 8:30, 4:41; Lk 9:21, 10:22-24; Mt 16:20; Jn 2:24, 8:25-29, 10:24-38, 12:34], and reluctant to have his powers tested [Mk 8:12; Lk 11:29, 23:8; Mt 4:7, 12:39, 16:4; Jn 2:18]. He was likely neither liar nor lunatic, but rather a preacher, faith-healer, and apocalyptic prophet who in the months leading up to his anticipated execution came to believe he was the Jewish Messiah and even the divinely-special savior of mankind.

Resurrection. At his death the apostles abandoned Jesus in panic, even though they should have been expecting his resurrection if they had indeed witnessed his miracles, heard his divinity claims, and heard him say at least four times [Mk 8:31, 10:34; Mat 16:21, 17:23, 20:19; Lk 9:22, 18:33, 24:7, 24:46] that he would "rise from the dead" or be "raised to life" "on the third day". The New Testament accounts of the resurrection appearances develop over time from silent to vague to contradictory to fantastic. The Empty Tomb story could have resulted from a discreet reburial or removal -- perhaps by a disciple, as in a rumor reported in Mt 28. Possible conspirators were Joseph of Arimathea and Mary Magdalene, a longtime disciple [Lk 8:2] "out of whom [Jesus] had driven seven demons" [Mk 16:9, Lk 8:2] and who (unlike any apostle) attended both the crucifixion and entombment. She was the first to visit the tomb on Easter [Mt 28:1, Jn 20:1], and the possibility of removal [Jn 20:2,14,15] was not unimaginable to her. She weepingly lingered [Jn 20:11] after the apostles left the empty tomb, and thereupon was the first [Mk 16:9, Mt 28:9, Jn 20:14] to claim seeing an appearance. The appearances were suspiciously exclusive: "God raised him on the third day and caused him to be seen. He was not seen by all the people, but by witnesses whom God had already chosen" [Acts 10:40-41]. Many of the "appearances" seem to have been unimpressive to the disciples who heard about them and even to those who witnessed them:

- But they did not believe the women, because their words seemed to them like idle tales. [Lk 24:11]
- When they heard that Jesus was alive and that she had seen him,

they did not believe it. Afterward Jesus appeared in a different form to two of them [Mk 16:11-12]

- These returned and reported it to the rest; but they did not believe them either. [Mk 16:13]
- When they saw him, they worshiped him; but some doubted. [Mt 28:17]
- Jesus himself came up and walked along with them; but they were kept from recognizing him. [Lk 24:15-16]
- she turned around and saw Jesus standing there, but she did not realize that it was Jesus. Thinking he was the gardener, she said ... [Jn 20:14-15]
- Jesus stood on the shore, but the disciples did not realize that it was Jesus. [Jn 21:4]

Early Christians probably combined the idea of spiritual resurrection or an empty tomb with these cases of "idle tales" and hallucinatory mistaken identity, and embellished the result with stories ("written that you may believe" [Jn 20:31]) like the wound examination by Thomas [Jn 20:19-29].

Missing evidence. A divine Jesus could trivially create new miracles to unambiguously vouch for some modern school of Christianity. For the gospel accounts of Jesus to be believable, two kinds of evidence would have to surface:

- Textual discoveries that Jesus did not believe in the literal truth of the entire Old Testament, and that the unjust Christian notion of eternal damnation is a misunderstanding.
- Compelling corroboration of gospel miracles through physical artifacts (e.g. the Shroud of Turin) or historical records (e.g. of the three-hour darkness on Good Friday).

However, available extra-scriptural records do not corroborate the gospel miracles. Christian apologists often claim that if false, the gospel traditions would have been refuted and discredited by skeptics in 1st-century Palestine. However, there is no indication that the Jesus movement was important enough then to merit the sort of early written debunking that would have been preserved despite skeptical apathy and Christian hostility. Except for the stolen-body rumor denied in Mat 28, the earliest records of anti-Christian skepticism date after the first century and are preserved mainly as excerpts in Christian rebuttals. Celsus (quoted by Origen) dismissed the miracles as the "tricks of jugglers" that he said are "feats performed by those who have been taught by Egyptians", and the Jewish slander reported by Tertullian claimed the empty tomb was faked.

The 1st-century Jewish historian Josephus is hard to count as anti-Christian, even after discounting his affirmation (unnoticed by all of his earliest Christian commentators) of the resurrection as an interpolation. Josephus may have written that Jesus "performed

surprising works" and even that he was believed to have been resurrected, but the (possibly interpolated) mention is only in passing. Josephus devotes more space each to John the Baptist and James, and while reporting much minutiae over the entire period during which Jesus lived, does not mention:

- the Christmas Star that disturbed Herod and "all Jerusalem" [Mt 2:3],
- Herod's massacre [Mt 2:16],
- the Good Friday earthquake [Mt 27:51],
- the Good Friday resurrectees that "appeared to many people" in Jerusalem [Mt 27:53], or
- the Good Friday 3-hour darkness "over all the land" [Mk 15:33, Lk 23:44, Mt 27:45].

These events in fact went unnoticed by every non-Christian writer, including the historians Seneca and Pliny the Elder. (Syncellus quotes a lost text of the Christian historian Julius Africanus which itself cites a lost text by Thallus: "Thallus calls this darkness an eclipse". The identification of Thallus' eclipse with "this darkness" might just be in the mind of Julius Africanus, and Thallus at any rate cannot be reliably dated as writing independently of the gospels.) The Alexandrian philosopher and commentator Philo outlived Jesus by 15 or 20 years, and as a visitor to Jerusalem should have met witnesses to the Easter miracles. His silence suggests that Jesus and his followers did not make the early impression that they should have if the gospels were true.

Implausibility. The gospel story of a Hebrew faith healer in the backward Roman province of Palestine seems an unlikely self-revelation for the omnipotent, omniscient, omnibenevolent Creator of the universe:

- Why such ambiguous and picayune miracles? Why not raise a new mountain in the desert, or install a new star in the heavens?
- Why such vague and equivocal claims of divinity?
- Why after his resurrection appear so ambiguously, so briefly, and to only his disciples? Why not -- after perhaps a more convincing execution, e.g. beheading -- march back to Pilate and Herod and ascend in front of Jerusalem assembled?
- Why not write his revelation himself, and ensure that it survive in perfect copies? Why not include in it indisputible authentication, e.g. by predicting a fundamental physical constant?

The God of the Bible is far too pedestrian in his works, parochial in his concerns, petty in his decisions, and primitive in his policies.

Works. In the gospels Jesus heals the sick, revives the recently

deceased, calms a storm, walks on water, and multiplies food. The god of the Torah makes appearances, speeches, promises, and predictions; raises the dead; and takes credit for various plagues, fires, floods, astronomical events, victories, healings, and deaths. It is implausible that the Creator's works would be so confined to ancient times and so apparently constrained by ancient imaginations.

Concerns. After creating billions of galaxies in Genesis, the god of the Torah is implausibly obsessed with the family of Abraham and the Jordan valley where they live. It seems implausible that an omnibenevolent, omniscient, infallible deity would entrust a few fallible men in a backward corner of the world with such paltry evidence and then demand that everyone else either hear and believe them or suffer eternal damnation.

Decisions. In the gospels Jesus damns entire towns [Mt 11:23], compares non-Israelites to dogs [Mt 15:26], and affirms even "the smallest letter" [Mt 5:18, Jn 10:35] of the Torah. The god of the Torah tests and torments his followers, commits mass murders of e.g. Noah's flood victims and the firstborn sons of Egypt [Ex 12:29], creates linguistic division for fear of an ancient construction project [Gen 11:6], and curses mankind because Adam dared to "become like one of us, knowing good and evil" [Gen 3:22]. It is implausible that the Creator of the universe would be so petty and wicked.

Policies. The god of the Torah promotes or demands extravagant worship, dietary taboos, animal sacrifice, repressive sexual codes, human mutilation, monarchy, subjugation of women, slavery, human sacrifice [Lev 27:29, Jud 11:30-39], and mass murder of even infants [Ex 11:5, 1 Sam 15:3]. In the gospels Jesus affirms the Torah and promises sinners not a thousand years' torture, nor a million or a billion, but an *eternity* of excruciating torture by fire [Mt 18:8]. It is implausible that the Creator of the universe would promote such primitive and evil policies.

Cascading implications. If the existing evidence about Jesus of Nazareth is considered a convincing proof of his divinity, then many other things can be proven with similar evidence.

- *Miracles* were reported commonly in ancient times and are attested in many other religions. Christians might argue that competing miracles were wrought by demons, but those very miracles could be used by a competing religion to justify the same claim about Jesus' miracles.
- *Martyrs* have been common throughout human history. If dying for a belief can show the belief is true, then the kamikazes of Japan showed that Emperor Hirohito was divine. Note that Peter and James are the only resurrection witnesses who the New Testament names (John 21:18,19, Acts 12:2) as martyrs, but there is no evidence that recanting their presumed belief in physical resurrection could have saved them. All other Christian martyrs

died, like the kamikazes, for what they were told and not for what they witnessed.

- *Prophecies.* No non-trivial prophecy in the Bible has both a) been documented as having been made before the predicted event and b) had its fulfillment documented independently of the Bible itself. If self-fulfilling prophecy is considered valid, then for example the Book of Mormon is a valid prophetic text.

Gospel sources. The gospels were stitched together decades after the crucifixion by non-eyewitness zealots freely borrowing from oral traditions and now-lost earlier texts.

- *Other gospels*. At least a dozen other gospels (e.g. of Thomas and Peter) are known from whole texts, fragments, and ancient references, but were not deemed by the early Christians to be divinely inspired.
- *Differing manuscripts* show that the gospels have undergone insertions, deletions, additions, and revisions.
- *Copying*. Matthew and Luke are based in part on copying from Mark and in part apparently on a now-lost earlier compilation of Jesus sayings.
- *Anonymity, Contemporaneity*. The gospels were written 35-60 years after Jesus' death, and (unlike every other intact work of classical nonfiction) no authors are identified in the earliest copies. Only about a century later did the gospels become associated with the names of their alleged authors. Writing extensively twenty years after Jesus' death, Paul gives no hint that any gospel had yet been written down.
- *Mark* was written c.65-70 by an unknown author who later church tradition said was an associate of the apostle Peter. The earliest copies of this gospel end abruptly at 16:8 before any visions of the risen Jesus, which were added later in various differing endings.
- *Matthew* was written c.70-80 by an unknown author who later church tradition identified with the apostle Matthew, but the text heavily quotes the non-eyewitness Mark rather than providing an independent eyewitness account. Matthew changes (21:5 vs. Mk 11:7) or embellishes (2:15, 2:23) its narrative to make it fulfill Old Testament prophecies.
- *Luke* was written c.80 by a supposed companion of Paul. Luke is confused (4:23, 31, 44; 24:12) about Palestinian geography. Writing after the fall of Jerusalem, Luke in 21:8 modifies Mark 13:6 to say the end is not necessarily near.
- *John* was written c.90 by an unknown author who is ambiguously identified (in the third person: 21:24) with the apostle John only in the final chapter, which is itself an apparent addendum.

Gospel contradictions. Among the many minor contradictions and inconsistencies in the gospels are several that cast significant

doubt on the gospels' central message of a divine messiah foretold by the prophets.

- *Genealogy*. Wildly contradictory genealogies for Jesus are given in Mt 1 and Lk 3, which cannot even agree on the father of Joseph.
- *Birthplace*. Lk 2:4 and 2:39 say Joseph and Mary lived in Nazareth before Jesus' birth, but Mt 2:23 says Joseph only later moved his family to "a town called Nazareth".
- *Birthdate*. Luke says Jesus was born during [2:2] the census of Quirinius and before [1:5] the death of Herod. The census was in 6 CE, but Herod died in 4 BCE.
- *Chronology*. John indicates Jesus' ministry lasted two or three years, while the earlier Synoptic gospels indicate one. John says Jesus cast out the money changers at the beginning of his ministry, while the Synoptics say it was right before his crucifixion.
- *Second coming*. Jesus said [Mt 16:28, Lk 9:27] some "standing here" would live to see "the kingdom of God". Jesus also said [Mk 13:30, Lk 21:32, Mt 24:34] that "this generation" would not pass away before the "see[ing] the Son of Man coming in clouds with great power and glory" as well as a "distress" "never to be equalled". Jesus' audience of course saw no such "kingdom" or "coming", and no "distress" like e.g. the Black Death or Holocaust.
- *Appearances*. The poor geographer Luke places resurrection appearances only around Jerusalem [Lk 24:33,49], while the other three gospels [Mk 16:7, Mt 28:10-16, Jn 21:1] report Galilee appearances.

Gospel apologetics. Certain assertions and omissions in the gospels seem to either suspiciously deny or unwittingly create embarrassing alternative explanations for the claims therein.

- *Self-fulfilling prophecy*. The gospels repeatedly relate [Lk 2:4, Mt 2:15, 21:4, 27:9, Jn 19:23, 36] hard-to-verify (and easy-to-fabricate) details and then cite them as fulfillment of prophecy. Each of these details is in only one gospel.
- *Vouching*. The author(s) of John protest (19:35 and 21:24) that the testimony quoted in this gospel is true, and admit (20:31) it has "been written so that you may believe". The 2nd letter of Peter claims [1:16] the gospels are not "cleverly invented stories", then warns [2:3] that "false prophets" will employ "stories they have made up".
- *John dies*. John 21:23 (in the appended final chapter) makes an excuse for Jesus' apparent promise that John would not die before the second coming.
- *Empty tomb*. Alone among the gospels, Matthew [27:64] alleges an order by Pilate that Jesus' tomb be guarded to prevent his

disciples from secretly removing his body. Matthew 28 reports a widespread story of such a secret removal and attempts to discredit it by saying Pilate's guards were bribed. In the other gospels the first disciples to check the tomb encounter no guards.

- *Appearances*. In order of writing, the gospel accounts of Jesus' resurrected appearances become increasingly elaborate. None of the alleged (and almost certainly pseudepigraphic) letters of Peter, James, Jude, and John mention an empty tomb or a physical resurrection, even in contexts [1 Pet 3:18, 1 Pet 5:1, 2 Pet 1:16] where one might expect them to. The first written account of appearances (1 Cor 15) vaguely lumps them together with post-ascension manifestations to Paul in a discussion of spiritual resurrection, making them suspect as accounts of bodily resurrection. Original Mark claims an empty tomb but describes no appearances. Matthew says simply that the two Marys and later the Eleven "saw him" but "some were dubious". The Longer Ending of Mark says Jesus appeared "in a different form" [Mk 16:12] to two disciples, and simply "appeared" to the Eleven. Luke elaborates on both of these episodes, building the latter into an account that approaches the full Doubting Thomas story finally told in John. Thus, reports of the resurrection become more assertive as the accounts grow more removed from the actual events.
- *Eyewitnesses*. There is no reliably first-hand testimony to the physical resurrection of Jesus. Paul does not claim to be such a witness. Original Mark contains no appearances at all. Matthew is anonymous and contains no assertions of first-hand witness by the author. The anonymous author of Luke admits he was not an eyewitness. In what appears to be an addendum, the anonymous author of John vaguely refers to "the beloved disciple" in the third person as "the disciple who testifies to these things and who wrote them down" [21:24], and otherwise makes no assertions of his own eyewitness.

1.2. Philosophy / Epistemology

Epistemology: the study of knowledge.

1. **Philosophy Of Mind**: the study of the faculty for thinking and knowing.
2. **Philosophy Of Science**: the study of scientific knowledge.

Knowledge

Knowledge is justified true belief. Belief in a proposition p is justified if 1) it is developed though a process that reliably yields truth, 2) it is appropriately caused by the fact that p is true, and 3) it would generally not be held if p were false. The reliability criterion entails that synthetic (i.e. inductive) knowledge is always provisional. The causal and counterfactual criteria entail that whether a true belief counts as knowledge depends on inherently imprecise

judgments concerning whether the believer is accidentally right. Operationally, a belief is justified if and only if it is convincing and defensible.

Truth

Truth is logical and parsimonious consistency with evidence and with other truth. **Evidence** is any and all perceived circumstances.

The **Principle of Parsimony** (or **Occam's Razor**) is that the simpler of two explanations is to be preferred when they are otherwise equivalent.

Humans have proposed several criteria for truth.

- The **Correspondence Theory of Truth** is that the terms of true propositions map to elements of reality in a way that validates the proposition.
- The **Coherence Theory of Truth** is that true propositions are those in the system of mutually coherent propositions that is more complete than any rival system.
- The **Pragmatic Theory of Truth** is that true propositions are those that are most useful to believe and that are thus "fated to be ultimately agreed to by all who investigate".

The Correspondence Theory begs the question by assuming that reality can be known directly and certainly. Depending on the meaning of 'complete', the Coherence Theory either reduces to the Correspondence Theory, or it makes truth a purely social (or divine) construct. The Pragmatic Theory either underdetermines the truth of certain propositions, or it reduces to a variant of the social version of the Coherence Theory. The proper notion of truth is coherence grounded in correspondence.

Origins of Knowledge

Propositions can classified according to the dependence of their truth value on their terms:

- **Analytic propositions** are those whose truth value can be deduced from only the definitions of their terms.
- **Synthetic propositions** are those whose truth value cannot be deduced from only the definitions of their terms.

Epistemic Provisionality. All synthetic propositions (including this one) can only be known from experience and are subject to doubt. It is logically possible that all experience is deceptive and that the world is illusory. The only absolutely certain truths are true analytic propositions and the synthetic proposition that something exists.

Cogito Ergo Sum. Descartes argued "I think, therefore I am". However, "I" could be illusory, and the fact of my thinking only warrants the certainty that something exists: cogito ergo est.

Meaning

The **denotation** (or **extension**) of a term is the set of entities it refers to. The**connotation** (or **intension**) of a term is the properties and concept(s) associated with it.

The **meaning**of a term is the context-sensitive connotation ultimately established by its relevant denotation and use.

The **Verifiability Principle** holds that a statement is propositionally meaningless (i.e. states no

proposition) if it is neither logically decidable nor empirically verifiable. **Positivism** is a stricter form of Empiricism that asserts the Verifiability Principle.

Theories of Meaning

Humans have proposed three sorts of explanation for meaning:

- The **Referential Theory of Meaning** is that the meaning of a term is the things in the world it refers to.
- The **Conceptual Theory of Meaning** is that the meaning of a term is the properties and concepts associated with it.
- The **Behavioral Theory of Meaning** is that the meaning of a term consists of the behaviors and dispositions associated with it.

The Referential Theory is confounded by terms that have the same referent but different meaning, such as 'morning star' and 'evening star'. The Conceptual Theory reduces to dictionary-like circularity for many concepts that can only be described by the word(s) to which they help give meaning. The Behavioral Theory is undermined by behaviors and dispositions that underspecify the meanings they are supposed to impart.

Theories of Knowledge

Humans fall into two camps depending on whether they believe synthetic a priori knowledge is possible:

- **Rationalism** is the thesis that some synthetic propositions can be known from reason alone and independent of any experience.
- **Empiricism** is the thesis that all synthetic propositions can only be known from experience.

Rationalism incorrectly assumes that existence arranges for reason to discover the nature of reality through introspection alone.

1.2.1. Philosophy / Epistemology / Philosophy Of Mind

Philosophy Of Mind: the study of the faculty for thinking and knowing.

1. **Essence of Mind**.
2. **Accidence of Mind**.
3. **Relations of Mind**.

Minds and ideas, like all of reality, consist ultimately of matter. Mental states are functional states consisting of causal relations among components for processing information.

Theories of Mind

Philosophers often divide all phenomena into three kinds:

- mind (or spirit or soul): that which can think and perceive;
- ideas (or universals or forms): that which can be thought; and
- matter (or substance): that which can be perceived.

Human theories of mind differ according to how they explain these phenomena in general and the Mind-Body Problem in particular. The **Mind-Body Problem** is the problem of explaining how mindless unconscious matter can give rise to or interact with mind and consciousness. Human theories

of mind include:

- **Idealism** is the thesis that reality consists ultimately of mind and ideas rather than matter.
- **Dualism** is the thesis that reality consists ultimately of both the material or physical and the ideal or mental.
  - **Substance Dualism** is the thesis that the material and the ideal or mental constitute two different and fundamental kinds of objects.
  - **Property Dualism** is the thesis that the material or physical and the ideal or mental constitute two different and fundamental kinds of properties. Property dualism can be a form of materialism if it says that mental properties are nevertheless fundamental material properties (analogous to mass or charge).
- **Materialism** is the thesis that reality consists ultimately of matter.
  - **Logical Behaviorism** is the thesis that mental states can be fully and best explained in terms of behaviors and behavioral dispositions.
  - **Identity Theory** is the thesis that mental states and brain states are identical.
  - **Functionalism** is the thesis that mental states are functional states consisting of causal relations among components for processing information.

Idealism is incorrect because its explanation of matter is either inadequate or unparsimonious. Dualism is incorrect because it unparsimoniously posits a realm of the ideal. Logical Behaviorism is unsatisfactory because behavioral explanations are too unwieldy. Identity Theory is incorrect because it holds that the essence of mind is its construction instead of its function.

1.2.1.1. Philosophy / Epistemology / Philosophy Of Mind / Essence of Mind

A **mind** is any volitional conscious faculty for perception and cognition.

Cognition

Cognition is the process of learning, reasoning, and knowing. **Learning** is the processing of experience into an increase in knowledge or behavioral effectiveness. **Reasoning** is the process of making and evaluating valid inferences.

Perception

Perception is the process of organizing sensation into experience. **Sensation** is the process of external influence on a monitoring or control system. **Experience** is any relatively unified and coherent interpretation of related contemporaneous sensations.

Consciousness

Consciousness is awareness of self and environment. **Awareness** is the direct and central availability of information in a monitoring or control system.

Volition

Volition is the power or act of making decisions about an agent's own actions. A **decision** is the causing by a system of events which were not physically determined from outside the system but rather were at least somewhat contingent on the internals of the system, and which were not predictable except perhaps by modeling the internals of the system.

Free will is either of the doctrines that human choices are a) determined internally rather than

externally (volitional free will) or b) not pre-determined at all (indeterminate free will). Determinism is incompatible with indeterminate free will, but is compatible with volitional free will if agents have internal state that influences (and thus helps determines) their actions. Volitional free will is also compatible with forms of indeterminism in which the acausality is not so rampant as to undermine agent self-influence. Indeterminate free will requires indeterminism, but degenerates into uncaused chance if acausality confounds not only prediction of effect but also attribution of cause.

Since most effects seem caused rather than uncaused, and since the complexity of minds makes them hard to predict, minds appear to have at least weak free will. Weak free will is sufficient for assigning ethical responsibility to decision-making systems even in the face of complete determinism.

Do minds have strong free will, or can their decisions in principle be inferred from sufficient knowledge of prior circumstances?

Anti-materialists posit an immaterial soul or will that is free from both deterministic causality and random acausality. This notion violates the law of the excluded middle. Either the immaterial will is subject to (perhaps probabilistic but nonetheless causal) causes, or it is not. The same is true of material minds. The actions of an immaterial will could be said to be caused by its own internal causal processes, but the same can be said of material minds.

1.2.1.2. Philosophy / Epistemology / Philosophy Of Mind / Accidence of Mind

Non-essential but perhaps inevitable aspects of mind include subjectivity, intentionality, and affect.

Subjectivity

Objectivity is independence from a point of view or perspective that is inherently private. **Subjectivity** is dependency on a point of view or perspective that is inherently private. **Subjective experience** is the private phenomenal aspect of experience, the vivid feeling of what an experience is "like".

Subjective experience consists of complex associations among perceptions, and necessarily occurs in systems having such associations. If a subjective experience is not "like" anything (i.e. not associated with any other perceptions), it is not a subjective experience at all.

Physicalism is the thesis that all facts can be described in physical (and thus non-subjective) terms. Some humans have what they call a "natural belief that collections of cells do not generate minds" [McGinn 1999] and that therefore physicalism must be false.

Such a belief seems only as "natural" as the belief that collections of atoms do not generate life, and just as unjustified. The operation of e.g. the human brain does not mysteriously *cause* consciousness, but rather it simply *constitutes* consciousness.

Qualia are ineffable intrinsic subjective qualities of perception, such as the redness of red, beyond the functional or dispositional properties of perception. Qualia are taken by opponents of physicalism to be a mysterious phenomenon that physicalism cannot explain.

However, qualia do not exist, because the functional and dispositional properties of perception *can*, in fact, explain the subjective qualities of perception. The functional role of certain

sorts of perceptions in a conscious system necessarily and understandably entails that the system will report qualia. Thus there are no ineffable intrinsic subjective qualities of perception beyond its functional qualities.

The **Knowledge Argument** is an argument made by Frank Jackson in 1982 purporting to show that physicalism is false because knowledge of all the relevant physical facts does not include, for certain experiences such as the redness of red, knowledge of what it is like to have them before they are had. Jackson hypothesizes in the distant future a brilliant neuroscientist Mary spending her whole life in a colorless room learning all the physical facts about seeing the color red. Jackson claims that only when Mary sees something red can she learns the new fact of what redness is like, and that therefore physicalism is false.

Jackson's argument fails because it ignores the difference between memorizing an algorithm and executing it. The experience of the redness of red consists in the operation of a complex set of functional components for processing information. While we can conceive of Mary having serial access to arbitrarily many memorized facts about such components, we cannot conceive of her having a large enough working memory or a fast enough mind to "manually" perform the operations "in her head" in order to recreate the experience of redness. Similarly, Mary could memorize the sequence of pixels in a monochrome bitmap and yet still not be able to mentally visualize what the bitmap will look like -- even if it is an image of a favorite drawing which she had already memorized in arbitrary detail.

A **zombie** is a hypothetical creature that is stipulated to lack subjective experience but is behaviorally and physically indistinguishable from a human. The conceivability or logical possibility of zombies is taken by opponents of physicalism to show that physicalism is false.

It seems impossible to conceive of a creature that lacks subjective experience but nevertheless exhibits all the self-reporting behaviors of humans that help us to ascribe subjective experience to them. Therefore, zombies are inconceivable and do not show physicalism to be false.

Intentionality

Intentionality is aboutness -- the property of being about, directed at, or suited for.

A system has intentionality by virtue of its potential and actual causal relations with the world.

The **Chinese Room** is a thought experiment devised by John Searle in 1980 to show that there cannot be intentionality or understanding in a formal symbol manipulation system such as a room in which a speaker of English manually executes an algorithm allowing the room to pass the Turing Test in Chinese. Searle claims that intentionality "is a biological phenomenon, and it is as likely to be as causally dependent on the specific biochemistry of its origins as lactation [or] photosynthesis". Searle charges that functionalism is a form of dualism because it says mind is in principle independent of the specific biochemistry of the brain.

The human in the Chinese Room does not understand Chinese, but the human running the algorithm implements a system that does indeed understand Chinese. The system has intentionality by virtue of the

causal relations that allow it to correctly answer questions posed to it in Chinese. Intentionality is a formal or informational property, whereas lactation and photosynthesis involve chemistry and energy. Simulated thinking can indeed produce understanding, just as simulated musical composition can indeed produce a sonata. If a functional explanation of mind is "dualistic", then so is a functional explanation of long division or carburetion.

Affect

Affect is a general and often undirected negative or positive attitude, beyond overall sensory or cognitive state, that influences motive and colors perception. Is affect indeed an inevitable property of any volitional system with complex motives?

1.2.1.3. Philosophy / Epistemology / Philosophy Of Mind / Relations of Mind

Mind and Object

Concepts are abstractions induced by minds from instances. Concepts are the products of the not-fully-understood facility by which a mind induces general properties from instances, and are themselves the not-fully-understood facility by which a mind recognizes those general properties in other similar instances.**Ideas** are concepts. **Universals** are kinds or categories of terms that are related according to shared properties. Human theories about universals are of three general kinds:

- **Realism** is the thesis that universals are essences that have existence independent of any instances.
- **Conceptualism** is the thesis that universals exist only as mental concepts.
- **Nominalism** is the thesis that universals are merely names given to groups of similar instances.

Universals do not exist independently of the instances that instantiate them and the minds that conceptualize them.

Mind and Minds

The **Other Minds Problem** is the problem of ascertaining whether external realty and other minds actually exist or merely appear to exist. **Solipsism** is the thesis that external reality and other minds do not actually exist. Solipsism incorrectly concludes not-X simply because X cannot be known with absolute certainty, and thus ignores the preferred conclusion of probably-X.

Mind and Identity

A mind is identical with its closest close-enough continuous-enough continuer. Processes that preserve mental (and thus personal) identity include:

- Deciding
- Incremental or continuous learning or forgetting
- Sleeping
- Locally continuous displacement through space, including e.g. teleportation via a portal
- Incremental transformation, e.g. through neuron-by-neuron replacement with computer chips

By contrast, the following processes do not preserve identity, usually because of being not continuous or not continuous-enough:

- Sudden irreversible complete amnesia
- Discontinuous teleportation, e.g. through disassembly and reassembly

- Discontinuous transformation, e.g. through mind uploading or restoration
- Reincarnation
- Duplication
- Simulation

It is perhaps logically possible for a single mind to fission continuously into more than one, or for more than one to continuously fuse into one, with identity being preserved in both cases. Chaotic or quantum effects probably make such fission or fusion physically impossible, since they might make it impossible to precisely synchronize the functioning of the duplicate components during the transition.

Mind and Spacetime

As noted by Dennett, the subjective sense of *here* -- the observer's spatial location -- is fixed by the content of mental events, and not by their spatial location. The subjective sense of *now* -- the observer's temporal location -- is similarly fixed by the content of mental events, and not by their temporal location.

Materialism implies that consciousness is distributed over space and time in a material substrate of mind such as the human brain. Thus there is no moment in time or point in space at which a thought enters consciousness. Asking when precisely did a material mind become conscious of an event is like asking when precisely did the British Empire learn of the signing of the treaty that ended the War of 1812. (The Battle of New Orleans was fought two weeks after the treaty was signed, by soldiers that had not yet heard of the signing.)

Mind and Artifact

Functionalism implies that, in principle, an artificial mind is possible, and that therefore a machine could think.

The**Turing Test** is an assay for intelligence in which an interrogator using teletyped queries attempts to distinguish between a certified intelligence and a candidate intelligence. A rigorous interrogator can pose lines of questioning that can only be answered by use of the perceptive inductions that are the essence of intelligence. Not every intelligence could pass such a rigorous Turing Test, but everything that passes such a Turing Test is an intelligence.

Roger Penrose argues that the human mind is not computable because, given a formalization of one's mind and the Godel sentence for one's mind, a human mind allegedly could recognize the sentence as true whereas the formalized computation could not. Penrose errs in assuming one could know a formalization of one's mind and correctly believe in its consistency. Godel's Theorem merely shows that any formalizable reasoning faculty could not correctly believe in its own consistency.

Mind and Supermind

These are some of the levels of information-processing ability:

- **Sentience** is the capacity for sensation.
- Cognition is the process of learning, reasoning, and knowing.
- Consciousness is awareness of self and environment.
- **Intelligence** is the ability to make, test, and apply inductions about perceptions of self and world.

- **Automentation** is the ability of a mind to engineer all of its internal and external information storage and processing.

Automentation can be superior to regular intelligence in efficiency, flexibility, speed, capacity, bandwidth, and network associativity, but not in cognition. There are no forms of reasoning or kinds of knowledge that are in principle inaccessible to regular intelligence.

Mind and Limits

There are several ways in which minds are limited in theory and in practice.

- Logical Limits
  The Principle of Non-contradiction requires that no mind can correctly believe both a proposition and its negation. Indeed, all of the conclusions of logic are binding on all possible minds, as logic is in fact the study of valid inference.
- Computational Limits
  If functionalism implies (as seems likely) that the logical limits on computability apply also to all physically possible minds, then several implications follow.
  - Godel's Incompleteness Theorem would then imply that no mind with a formalizable reasoning system can be both consistent and complete.
  - Neither the Decision Problem for the predicate calculus nor the (equivalent) Halting Problemcould be solved by any physically possible mind.
  - Certain computational problems (such as sorting a list of N elements) could not be solved by any physically possible mind in less than an amount of time that is a function (such as log N) of the size of the problem.
- Epistemological Limits
  It seems likely that no mind could ever achieve
  - apodictic certainty about synthetic knowledge; or
  - a proof of God's existence.
- Physical Limits
  - **Bremermann's Limit** is the maximum processing speed (2×10^{47} bits per second per gram) of a self-contained material system. Bremermann's Limit derives from the Heisenberg's Uncertainty Principle and Einstein's principle of mass-energy equivalency. The finite age and mass of the universe combine with Bremermann's Limit to constrain the amount of thinking that any material mind can have done.
  - The **Bekenstein Bound** is the physical limit of information density.
  - Heisenberg's Uncertainty Principle implies that no mind can completely know the momentum of a particle at a particular position in space, or the energy of a particle at a particular moment in time.
  - The finiteness of the speed of light limits how big and nimble a material mind can be, as well as how far it can sense or influence circumstances.
  - The laws of thermodynamics require that no material mind in a closed system can create energy, decrease entropy, or indefinitely sustain a given level of operation.
  - No material mind can travel backwards in time. The ability to do so would eliminate the mind's computational limits and physical limits.
- Biological Limits
  Biological minds necessarily inherit a powerful drive to sustain self and kind. However,

intelligence and volition can in principle allow a mind to overcome any such biological imperative.

- Psychological Limits
  Human minds are subject to many psychological limits in the areas of memory, perception, attention, concentration, volition, and cognition.

1.2.2. Philosophy / Epistemology / Philosophy Of Science

Philosophy Of Science: the study of scientific knowledge.

Definition of Science

Science is the study of regular objective phenomena through empirical induction and logical deduction. The **scientific method** consists of observation and measurement, induction of hypotheses and deduction of consequences, experimental or empirical testing of those consequences, reproducibility of results, and competition for agreement in the marketplace of ideas.

Discovery is the learning of a principle or fact that was already in effect. **Invention** is the creation of a method or mechanism that was not already in operation. A **hypothesis** is a rigorous explanation that has not already been proven. '**Theory**' can mean either a proven or unproven hypothesis. A **fact** is a synthetic proposition that is demonstrably true. Principles and facts are discovered (not invented) because they were already in effect. Theories are invented (not discovered) because the explaining that they constitute was not already happening, even though the principle they describe might have been. Thus, Darwin can be said both to have invented the theory of evolution and to have discovered the principle of evolution.

Scientific Provisionality

The propositions of science are mainly synthetic ones, and the truth of any synthetic proposition is provisional and subject to revision according to new evidence or better interpretation of evidence. Science tends to converge asymptotically and almost monotonically on truth.

Critics of skepticism point to the scientific revolutions in the past to question the validity of what science asserts in the present. They cite Kuhn's theory of paradigms, Einstein's transcendence of Newton, discoveries of unforeseen physical forces and particles, various premature announcements of the end of physics, and various incorrect predictions of technological barriers.

First, technology and science are different. Those who incorrectly denied the technological possibility of powered or supersonic flight did not deny the scientific reality of birds or gunshots.

Second, science in the past left vast swaths of phenomena unexplained. The darkness of infinite star-filled space was considered Olber's Paradox until well into the 20th century. The Sun was a marvel of inexplicable energy as recently as 1900. Disease and heredity and the blueness of the sky were still unexplained in 1850. Electricity and magnetism were spooky curiosities as recently as 1800. In 2000 there were still big mysteries about purposes and origins, but fewer marvels about what some phenomenon might possibly

be. Perhaps humanity's biggest marvel in 2000 was quantum action at a distance, followed distantly by minor marvels like dark matter, gamma ray bursters, and high-temperature superconductivity. Even a phenomenon as marvelous as mind has been demonstrated to be neurological -- although diehard dualists insist that consciousness is a true marvel.

Third, science converges toward truth even across some paradigm shifts. The Earth is still spheroid and still moves around the Sun, even though the Sun is now known to not be the center of the universe. Gravity still obeys Newton's inverse square law, even though relativity now explains gravity as geometry instead of as force. Momentum is still conserved, even though mass and energy are interconvertible. Since roughly the time of Darwin, there have been very few big questions for which science gave answers that were not even approximately correct. Perhaps the biggest mistakes in this time were the underestimations of the age and size of the universe.

Finally, humanity is now clearly converging on answers to the biggest scientific questions.

Science's Big Questions

The most interesting phenomena in nature are mind, life, and the universe itself. The big questions of natural science seek the origin, mechanism and fate of mind, life, and the universe. Before the 1860's, humans had only the beginnings of an answer to only one of these questions. Newton and a few others had figured out part of the mechanism of the universe, but the other eight questions were answered with a combination of biblical myths and wild guesses. By the end of the 1960's, humanity had, for all nine questions, outlined answers that will probably still be considered correct in two hundred, two thousand, and two million years.

- **What is the origin of the universe?** Spacetime itself and all the mass-energy in it were created in the Big Bang some 15 billion years ago. Humans are beginning to understand how the laws of physics allowed for the Big Bang to happen, and are even proposing reasons why the laws of physics have to be as they are. However, it may not be knowable why the laws of physics exist at all.
- **What is the mechanism of the universe?** The universe consists of fermions and bosons interacting through gravity, electromagnetism, and the strong and weak nuclear forces. Humans can accurately model those interactions using General Relativity and the Standard Model of particle physics, and may be close to combining these two theories into a unified theory of the universe.
- **What is the fate of the universe?** There appears not to be enough mass in the universe to halt its (perhaps asymptotic) expansion into a vast emptiness growing steadily colder and darker. Humans will soon know whether, on the other hand, there is enough mass to eventually reverse the expansion and collapse the universe in a hot Big Crunch.
- **What is the origin of life?** Life based on ribonucleic and amino acids arose on Earth four billion years ago as a result of auto-catalytic chemical processes of increasing complexity. Humans are only beginning to understand the details of these processes and how improbable they might have been.
- **What is the mechanism of life?** Life on earth operates according to the basic principles of

biochemistry and develops through evolution by natural selection. Humans will long be filling in the details of molecular and cellular biology and tracing the history of evolution.

- **What is the fate of life?** Due to senescence or chance, individual organisms eventually die; and due to environment or chance, species usually evolve or become extinct. Humans are beginning to understand and protect the ecosystem of Earth, and are investigating possible ecosystems elsewhere.
- **What is the origin of mind?** Intelligence developed slowly over the last million or two years among social post-arboreal omnivorous tool-using bipedal primates, resulting in language by 50 Kya or 100 Kya. Humans are investigating precisely how intelligence evolved on earth, how improbable it was, and whether it has arisen elsewhere. Humans may never develop definitive answers to these questions.
- **What is the mechanism of mind?** The human mind is the result of electrochemical neural processes in the human brain, and artificial minds seem producible from simpler functional components. Detailed understanding of mental mechanisms will require lots of engineering and even more reverse-engineering.
- **What is the fate of mind?** The human mind and personality cease to exist when the human brain ceases to function. Humans may someday be able to extend the function of the brain indefinitely.

Why Science Works

Humans sometimes ask: why does science work so well? The answer has two parts. First, the universe turns out to consist fundamentally of Nature and not Spirit: of lawlike and unwilled objective regularity, as opposed to randomness or mysterious volition. Second, science's method of skeptical empiricism and competition between ideas is better at elucidating the universe's regularity than are alternative methods like faith and mysticism. If the universe were in fact fundamentally controlled by volition, then faith would work better than science. If the universe were in fact fundamentally subjective (at the level of understanding and not merely observation), then mysticism would work better than science. Note that a very important aspect of the universe is in fact mysteriously volitional: the behavior of living and conscious systems. However, the volition of these systems is now confidently believed to be not a fundamental aspect of the universe, but rather an epiphenomenon of fundamental lawlike and unwilled regularities. While science can show that life and mind arose as epiphenomena, science must work hard to find regularities in the complex behaviors of such systems. The complexity appears irreducible, and there is no prospect that faith or mysticism will in these areas ever work better than science.

Science has been so spectacularly successful in the last 150 years that people tend to consider it to be a self-contained worldview independent or inclusive of its entire philosophical foundation. Science as a method would still work quite well if naturalism and materialism were false in the ways proposed by their opponents. The success of science is not a completely dispositive argument against supernaturalism or anti-materialism, though it of course provides much of the raw materials for attempting such an argument. We should resist the urge to say that some philosophical positions are more scientific than others, because philosophy is more fundamental than science and deals with issues that are almost entirely outside science's domain.

1.3. Philosophy / Axiology

Axiology: the study of values.

1. **Ethics**: the study of how individual persons should affect other persons and other beings.
2. **Political Philosophy**: the study of how groups of persons should affect persons and other beings.
3. **Virtue Philosophy**: the study of how individual persons should conduct themselves.
4. **Aesthetics**: the study of beauty.

Definition of Values

A **value** is, in Philosophy, a principle or standard for considering something good or bad. **Good** is being pleasant or fit for a chosen purpose. **Bad** is being unpleasant or unfit for a chosen purpose. **Right** is accordance of a decision or outcome with ultimate (and not just proximate) goodness. **Wrong**is discordance of a decision or outcome with ultimate (and not just proximate) goodness.

Origin of Values

Values derive from intentions and appetites. **Appetites** are desires arising from capacities for pleasure and pain. Innate appetites are usually the result of evolutionary pressure for inclusive reproductive fitness. However, appetites can conflict with each other, with long-term inclusive fitness, and with intentions. An **intention** is a desire for a chosen goal. **Happiness** is the tendency of a being to have its appetites satisfied and intentions fulfilled.

The ultimate goal of most humans is self-preservation in any of three ways:

- personal survival: continuation of one's body, mind, and "soul"
- genetic survival: continuation of one's family
- memetic survival: continuation of one's memory and creations

A minority of humans choose alternative goals, such as pleasure, pain, knowledge, beauty, compassion, justice, ecosystemic survival, capability, serenity, or annihilation

An **intrinsic value** is a value which derives from an intention or appetite that is an end in itself, and is not purely instrumental to other intentions and appetites. An **ultimate value** is an intrinsic value the pursuit of which is not compromised by the pursuit of any other value.

Justification of Values

Humans have no evidence that the universe has an inherent objective purpose, and so the universe has no goal whose desiring could be the basis of a value. The universe is not inherently either good or bad, and neither are the appetites of humans and other known beings in it.

In the absence of objective purpose or inherently good or bad appetites, humans seem free to choose their own purposes and values. Can there be an objective rational basis for values? It does not seem impossible, but no human choice of values has been shown to be justifiable through objective reason alone. Instead, such choices must ultimately be based at least in part on appeal to appetites rather than to reason. This resort to arational appeal can be minimized by using it just to choose fundamental values, or better yet the criteria for choosing fundamental values. Several criteria for choosing fundamental values seem appealing:

- **Universality** is, in Axiology, the principle that to hold a fundamental value is to advocate it being held by all relevantly similar valuers.
- **Impartiality** is, in Axiology, the principle that a fundamental value cannot favor a particular thing over other relevantly similar things.
- **Maximality** is, in Axiology, the principle that if a value is fundamental then there being too much of it is impossible.
- **Compatibility** is, in Axiology, the principle that fundamental values must be relatively compatible with the natural appetites and desires of the valuer.

Humans divide into several schools of thought regarding the justification of values.

- **Cognitivism** is, in Axiology, the thesis that propositions about values can be objectively true or false.
  - **Naturalism** is, in Axiology, the thesis that the truth of propositions about values can be derived from facts about nature.
  - **Intuitionism** is, in Axiology, the thesis that the truth of propositions about values can only be derived from self-evident intuitions.
- **Noncognitivism** is, in Axiology, the thesis that propositions about values cannot be objectively true or false.
  - **Emotivism** is, in Axiology, the thesis that propositions about values reduce to emotional expressions of approval and disapproval.
  - **Prescriptivism** is, in Axiology, the thesis that propositions about values reduce to exhortations and prohibitions.

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Naturalism is incorrect because there is no compelling way to argue
from 'is' to 'ought'. Intuitionism is incorrect because the axioms
about values are not self-evident in the way that are, say, the
axioms of mathematics. Both Emotivism and Prescriptivism are
partially correct, because assertions of values indeed have emotive
and prescriptive force, and are not objectively descriptive.
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Asserted Values

In a universe condemned to inexorably increasing entropy, we value extropy. **Extropy** is the amount of a system's intelligence, vitality, and capability for increasing its intelligence, vitality, and capability. As autonomous living intellects, we persons value intelligence and life and the autonomy they need to flourish.

Intelligence. We value not just information and knowledge. We value understanding and wisdom and especially the intelligence that both produces and includes them. **Understanding** is knowledge that is fundamental, recursive, and reflexive: it is central and irreducible, it supports and implies much other derivative knowledge, and it fixes itself and its knower in the landscape of other knowledge. **Wisdom** is the understanding of both one's purpose and how best to pursue it.

Life. We value the complexity and organized diversity that lies between rigid order and random chaos. Systems like life that undergo evolution by natural selection are the best source of such complexity and organized diversity.

Autonomy. We value the autonomy that is required by life and intelligence in order for them to flourish. Life needs autonomy to pursue the self-interest necessary for preservation of self

and kind. Intelligence needs autonomy to question assumptions and authority. We value justice, which allows each agent to enjoy the reasonably expectable results of its decisions and non-coercive actions.

Value Systems

The major human value systems are:

- **Pietism** is the thesis that the ultimate value is devotion to supernatural agency.
- **Collectivism** is the thesis that the ultimate value is the good of persons in groups.
- **Individualism** is the thesis that the ultimate value is the good of persons as individuals.
    - **Eudaimonism** is the thesis that ultimate value lies in individual happiness.
        - **Utilitarianism** is the thesis that the ultimate value is the greatest happiness for the greatest number.
        - **Hedonism** is the thesis that the ultimate value is pleasure.
        - **Asceticism** is the thesis that the ultimate value is serenity.
        - **Egoism** is the thesis that the ultimate value is one's own happiness.
    - **Stoicism** is the thesis that the ultimate value is virtue.
    - **Existentialism** is the thesis that ultimate values are created only by individual choices.
- **Survivalism** is the thesis that the ultimate value is inclusive reproductive fitness.
- **Pessimism** is the thesis that ultimate values are irrelevant.
- **Deontologism** is the thesis that ultimate value derives from rational imperative.
- **Altruism** is the thesis that the ultimate value is the happiness of others.
- **Extropianism** is the thesis that the ultimate value is extropy.

Pietism fails because there is no credible evidence of any supernatural agency. Collectivism fails because it is incompatible with the rights and incentives of individuals. Utilitarianism underdefines goodness as happiness. Hedonism fails because simple sensual pleasure eventually conflicts with more complex goals. Asceticism fails because it attempts to suppress natural appetites and intentions. Egoism fails because the inviolability of personal liberty eventually conflicts with its maximal protection. Stoicism underdefines goodness as virtuousness. Existentialism and Pessimism mistake important insights to be the last word. Survivalism commits the Naturalist Fallacy that the way things are naturally is the way one should want things to be. Deontologism too is a form of Naturalism that wrongly concludes 'ought' from 'is'. Altruism both conflicts with and fails to harness natural appetites and intentions.

If the 2nd Law of Thermodynamics didn't guarantee that entropy effectively always increases, then life would perhaps evolve runaway godlike powers, and those gods might not value extropy so much. What *would* an omnipotent omniscience value? worship? companionship? beauty? serenity? forgetfulness? oblivion?

1.3.1. Philosophy / Axiology / Ethics

Ethics: the study of how individual persons should affect other persons and other beings.

Nature of Ethics

Ethics consists in identifying the rights that each kind of entity has. A **right** is an entitlement of a being that persons will or will not affect it in a specified way.

Extropian Ethics

A **being** is any entity possessing life, sentience, or intelligent volition, and are the only entities that have rights. There are two classes of beings: persons and organisms. A **person** is any intelligent being with significant volitional control over how it affects other beings.

- All persons have the right to life and liberty.
- All beings have the right not to suffer torture or extinction.

Thus persons are obligated to minimize the incidence of

- deaths of persons;
- extinctions of species;
- aggression; and
- torture.

Subjects of Ethics

Groups. Groups of individual beings do not have volition or sentience, and cannot be subject to coercion or torture except insofar as their individual members are so subject. Thus groups per se have no separate right against coercion or torture. There *is* a sense in which some groups -- species -- are alive, and so species have the right not to suffer extinction.

Sub-Persons? A **dependent person** is a person who has less than the normal amount of intelligence, volition, or physiological independence. A **guardian** is a person who is responsible for the well-being of a dependent person and to that end may coerce that dependent person. Minor children are dependent persons, and their parents are usually their guardians. The other major group of dependent persons are the mentally disabled. Cetaceans and apes are not intelligent enough to be considered even dependent persons.

Super-Persons? No amount of mental or physical power makes any entity deserve more rights than persons. Bioengineered and artificial beings are fully persons if they meet the tests of intelligence and volition.

Pre-Persons. A being is also a person if it is of a kind that ordinarily are or become persons and has either significant cognition or both sentience and physiological independence. Viable human fetuses thus are dependent persons, in the same sense that minor children are. Genotypes of persons are not themselves persons, and have no right not to be modified.

Post-Persons. A person ceases to be a person when it permanently loses its life, intelligence, or volition. A person must be considered a dependent person if he does not want personal responsibility for any intermittent loss of intelligence or volition.

Personal Identity. A person is identified through time with its closest close-enough continuous-enough continuer. A person P1 constituted from the description and even

materials of a person P0 is not identified with P0 if the constitution process is discontinuous. It is logically possible to duplicate a person, even though the duplicate would not share in the identity of the person and would have the ethical status of a child of the original's age. It is also logically possible to split a person such that all continuers are equally close and all are close and continuous enough to preserve identity. In this case the continuers would share equally the predecessor's identity, and would have to assign among themselves all of the predecessor's unsharable personal and property relations. Similar reasoning applies to joined persons.

Organisms. Impersonal organisms may be owned by persons, and may be coerced or killed by their owning person or (if unowned and unaccessed) by any person. Genotypes of organisms are not themselves alive, and thus have no independent right against extinction. Bioengineered and artificial beings have the full rights of organisms if they meet the test of being alive.

Objects of Ethics

Property is anything that an agency has the exclusive right to possess, use, and assign.

- Property can be anything that is not a person and that can be created or controlled by a person.
- A person has a right to access any unowned resource to which they have been exercising continuing access.
- A person owns any unowned unaccessed thing over which he exerts original control.
- A person owns anything he creates from his property and resources rights.
- A person owns any property, property right, or resource right consensually assigned by its rightful owner.
- Each property, property right, and resource right of a person, upon his death, either goes to a chosen assignee or reverts to being unowned.

A **resource** is any physical or logical supply or space which exists without intelligent sustenance and is easy to use in part but hard to control as a whole, such as air, land, water, pollution sinks, sunlight, wind, views, fish, game, minerals, meteorites, space, orbits, bandwidth, public namespaces, etc. Polluting or monopolizing a resource is aggression against the persons who have been exercising continuing access to it. A **possessable resource** is one, such as land or sunlight, of which a part may be controlled such that any outsider's use of it is easily detectable by the controller. Even privatized property interests in unpossessable resources are subject to the tragedy of the commons, because the owner cannot readily identify who is violating his interest.

Property can consist only of possessable resources, artifacts, and intellectual property. An **artifact** is any material thing created by an intelligence. **Intellectual property** is property consisting of an original creation of information, including expressions (but not facts), inventions (but not discoveries), and reputations. **Copyright** is the right to reproduce an original expression such as text, images, audio, video, sculpture, or dance. A**patent** is the property right over an original invention. A **reputation** is the public or commercial esteem or identity of a person or a person's property. **Defamation** is damage to a reputation through deceptive expression.

Original expressions are the intellectual property of their creator or his assignee, but should not be granted full copyright. When media reproduction and distribution was expensive and its

ownership concentrated, copyright had the primary effect of ensuring commercial exclusivity rather than preventing non-competing or "fair" use. Digital technologies have made media reproduction and distribution asymptotically free, and so archaic copyright doctrine finds itself opposed to uses which cannot be prevented. (Although not protected by copyright, there seems to be no shortage of expressions such as fashions, jokes, and bumper stickers.)

Ownership of expression should give only the right to prevent its reproduction in cases of a) competition that diverts commercial benefit from the owner to the competitor, b) attributed use with unattributed defamatory modification, and c) unattributed use of any kind. Intellectual property in reputations should be recognized for as long as the commercial utility of those reputations. Anti-competition rights in expressions should be recognized for only as long as it might have taken before someone else created the same original expression. (For most expressions, this duration would be indefinite.) Intellectual property in an invention should be recognized for only as long as it might have taken before someone else invented it, or for as long as the ordinary product lifecycle in the relevant industry, whichever is longer.

Ethical Relations

Persons have no right to inflict negative externalities impacting property and resource rights, and no right to demand compensation for positive externalities.

Cooperation is the interaction among persons for mutual benefit. Cooperation is usually positive-sum even for direct and reversible exchanges, because the exchanging persons have differing needs or values. The **right of association** is the right of persons, except in cases of anti-competitive monopoly, to cooperate or decline to cooperate with whom they choose. Cooperation can take many forms. A **contract** is an explicit understanding among consenting agents to exchange with or affect each other in a specified way. **Marriage** is a form of contract that unites many of the property rights and liabilities of the marrying persons.

Aggression is the violation by a person of another person's rights, and consists only of: personal injury, damage to property, infringement of resource rights, coercion, fraud, anti-competitive monopoly, or inducement or deceptive incitement of third parties to any of these. **Coercion** is compulsion of one person by another through force or threat of aggression. **Fraud** is any attempt to profit by deceiving a person into making a choice intended to cause him economic harm relative to what would have been his undeceived choice. **Deception** is the statement of demonstrable falsehoods or the omission of relevant truths that has the intentional effect of encouraging a false belief in another person. **Theft** is the unjust and non-consensual taking of property from its rightful owner. **Anti-competitive monopoly** is the intentional control or denial of a person's participation in an industry by the coordinated action of the person(s) controlling that industry. **Torture** is the infliction of pain on any being as a result of the sadistic intention or callous negligence of a person.

Competition is the contrary efforts of persons to win the consent of some other person(s) to associate in some way. The infliction of opportunity costs through non-monopolistic competition does not by itself constitute aggression. Expression is only aggression if it involves deception that intentionally or negligently causes actual harm or serious risk thereof, for example by yelling "fire!" in a crowded (but not burning) theater. Non-deceptive incitement to aggression is not itself aggression.

Justice is the minimization, reversal and punishment of aggression. **Injustice** is unminimized, unreversed, or unpunished aggression. The minimization of coercion can itself

justify a minimal amount of coercion. Coercion should be reversed by payment of damages or, if possible, reparation of the original property or access rights to the coerced persons. Serious coercion should be punished by loss of freedom, personal interaction, and even life.

Liberty is volition in the absence of aggression. Thus justice can also be defined as the most liberty for the most persons. **Freedom** is significant volition: the power of making significant decisions about an agent's own actions. The freedoms of two persons can be in complete conflict, but their liberties by definition cannot.

1.3.2. Philosophy / Axiology / Political Philosophy

Political Philosophy: the study of how groups of persons should affect persons and other beings.

The State

A **state** is an organization of persons that has control and sovereignty over a particular region and the persons in it.

Purpose of the state

To meet their obligation to minimize death, extinction, aggression, and torture, the persons in a region join together in a social contract to create or authorize the state. The purpose of the state is to

- Effect justice (the minimization, reversal, and punishment of aggression);
- Provide aid and sustenance to persons in mortal danger;
- Protect species in danger of extinction;
- Prevent torture;
- Regulate natural monopolies; and
- Provide public goods.

Duties of the state

The specific duties of the state are therefore to

- Minimize, reverse, and punish foreign aggression
    - Deter and defend against foreign attack
    - Regulate international trade
    - Manage annexations and secessions
- Minimize, reverse, and punish domestic aggression
    - Minimize, reverse, and punish coercion
        - Prevent force and fraud
        - Protect property
        - Enforce contracts
        - Protect resource rights
            - Protect ongoing access to unowned resources
            - Collect rent for use (e.g. pollution) of unpossessable resources
        - Regulate bankruptcy
        - Regulate incorporation

        - Minimize, reverse, and punish anti-competitive monopolies
            - Regulate natural monopolies
            - Prevent anti-competitive artificial monopolies
    - Provide aid and sustenance to citizens and residents in mortal danger, such as
        - the indigent
        - dependent persons with no guardian
    - Prevent torture
    - Protect species and ecosystems

Powers of the state

The powers of the state necessary for carrying out its duties are to

- **Tax** - a taking of property by a state from a class of its subjects according to rule ordained in a duly enacted law.
    - Establish a currency as legal tender for public debts
    - Collect rent for use of unpossessable resources
        - Tax resource consumption and pollution
        - Rent resource access to the highest bidders
    - Tax consumption, income, or trade
- Take or regulate private property for fair compensation, to help to
    - Regulate natural monopolies
    - Prevent anti-competitive artificial monopolies
    - Prevent threats to public safety such as epidemic, flood, pestilence, and weapons of mass destruction
    - Protect species and ecosystems
- Establish police and regulatory services to prevent domestic aggression
- Establish a military to minimize, reverse, and punish foreign aggression
- Establish a judiciary to try cases of fact and law
- Regulate the definition of personhood for elections, citizenship, adulthood, marriage, incorporation
- Manage spaces annexed or donated to the state

Restrictions on the state

In no case may the state

- Commit torture
- Restrict any person's non-coercive expression or belief
- Establish or endorse any religion
- Treat persons inequitably on the basis of ethnicity, sex, age, or belief
- Deny any person equal representation
- Compel labor, except through wartime military conscription
- Take property without fair compensation
- Confiscate or tax wealth or inheritance, as opposed to the change in wealth through consumption, income, or trade

- Search or seize persons or property without a warrant of probable cause
- Compel self-incrimination
- Annex a space without the consent of a supermajority of the persons residing or owning property or accessing resources there
- Permit the secession of a region if
  - a supermajority in the region does not approve, or
  - secession threatens the security of the state, or
  - the region would get a free ride from the state's exercise of its duties.

Organization of the state

The state should practice the principle of federalism, so that each governmental function is performed by the most local unit of government that can perform it. The state should have separate legislative, executive, and judicial branches. The citizens of the state should exercise their power through elected representatives rather than directly through plebiscites.

Laws of the state

Contracts. The state should enforce contracts and thus prevent the coercion of one contracting person by the other. A person must exist to be coerced, and so covenants are not enforceable if no person has been assigned the guarantee constituted by the covenant. The state should regulate bankruptcy to prevent the theft that occurs when a bankrupt debtor assigns assets to one creditor over another.

Corporations. The state should allow the incorporation of fictitious persons for commercial purposes, with limited liability and equal ownership and control for each shareholder, as long as at least one shareholder agrees to unlimited liability. Thus corporations should be an elaborate form of limited partnership, where at least one full partner retains full personal liability for the corporation's debts.

Monopoly. Artificial monopoly should only be regulated to the extent it is anti-competitive. An important example of anti-competitive monopoly is when all the firms in an industry or region refuse to do commerce with employees or customers of a certain race. A **natural monopoly** is a continuous physical network that needs to reach almost every piece of property in a region, such as roads and distribution networks (but not sources or sinks) for water, electricity, natural gas, sewage, and wired telecommunications. Since the market cannot efficiently regulate natural monopolies, the state should do so.

Political Philosophies

The most influential human political philosophies differ primarily according to the extent to which they advocate state control of resources and private economic associations.

- **Anarchism** is the political system holding that the state should not exist because coercion is never permissible.
- **Libertarianism** is the political system holding that the state exists only to minimize coercion.
- **Welfare Statism** is the political system holding that the state should protect civil liberties, regulate unequal private economic association, and provide social insurance.
- **Socialism** is the political system holding that the state should protect civil liberties, regulate unequal private economic association, provide social insurance, and monopolize certain industries and resources.
- **Communism** is the political system holding that the state should monopolize all capital.

Libertarianism protects rights and promotes prosperity better than any other political system.

- Anarchism fails to minimize coercion because it favors liberty's theoretical inviolability over its practical protection. Anarchism fails to
  - Prevent coercion by strong persons and aggressive foreign states
  - Prevent aggressive use or pollution of unowned resources
  - Prevent unfair treatment of creditors by bankrupt debtors
  - Regulate natural monopolies
  - Prevent anti-competitive artificial monopolies
  - Provide aid and sustenance to the indigent
  - Prevent torture and extinction of organisms
- Welfare Statism violates the right of free economic association, and hinders prosperity by imposing inefficient regulations on the free market. The fundamental ethical mistake of Welfare Statism is the notion that it can be coercive (outside anti-competitive monopolies) for private parties to freely associate or decline to associate . For example, Welfare Statism holds that no adult should be free to sell labor for less than some government-determined minimum wage.
- Socialism violates rights of property and economic association, and hinders prosperity with inefficient regulations and collectives. The fundamental ethical mistake of Socialism is the notion that some industries or resources should not ever be private property.
- Communism eliminates property rights, and thereby cripples economic prosperity. The fundamental ethical mistake of Communism is the labor theory of value, which holds that value comes only from labor and that profit from capital ownership is exploitation.

1.3.3. Philosophy / Axiology / Virtue Philosophy

Virtue Philosophy: the study of how individual persons should conduct themselves.

Virtue

Virtue is any tendency or capacity to choose or behave in way that is good.

- Wisdom is the highest virtue.
- **Fortitude** is the capacity to overcome fear and endure misfortune.
- **Temperance** is the moderation of the appetites.
- **Fairness** is the practice of justice and the equitable reciprocation of cooperation.
- **Kindness** is sympathy and helpfulness.

In Greek philosophy the first four of these virtues were known as the natural or cardinal virtues. Christianity added the so-called

theological virtues of faith, hope, and charity. Faith in and hope for divine providence are misplaced. Wisdom entails not faith but skepticism, and the combination of wisdom and fortitude yields an optimism that is better than empty hope. As a theological virtue, charity (or love of God) is also hollow, as God does not exist.

The **Eightfold Path** is a prescription by Buddha of a middle path said to lie between asceticism and hedonism and said to end the suffering caused by desire.

1. Right Understanding: see things as they are.
2. Right Intention: resolve to follow the Path.
3. Right Speech: abstain from deception.
4. Right Action: practice compassion, abstain from aggression.
5. Right Livelihood: choose work compatible with the Path.
6. Right Effort: promote good and avoid evil.
7. Right Mindfulness: be aware of your thoughts, words, and actions.
8. Right Concentration: meditate on Oneness.

The Eightfold Path mistakenly assumes that no value can be maximal -- that any value can be desired too much. This is not true for values like extropy, intelligence, and justice.

The **Golden Rule** is the precept of reciprocity advocated by the Old Testament (Leviticus 19:18 c. 700 BCE), Jainism (Sutrakritanga 1.11.33, c. 500 BCE), Confucius (Analects 15:23, c. 500 BCE), Plato (c. 400 BCE), Jesus (Matthew 7:12, c. 30 CE) and others.

The Golden Rule's ethical value of reciprocity does not satisfy the axiological criteria of maximality and compatibility and so cannot by itself be a satisfactory system of ethics. However, when applied to meta-ethics it becomes the axiological criterion of universality, similar to Kant's categorical imperative.

Vice

Vice is any tendency to choose or behave in a way that is bad. The major human vices include:

- Sloth
  - Boredom, Ennui
- Timidity
  - Superstition
  - Cowardice
  - Shyness
  - Technophobia, Neophobia
  - Hypochondria
- Intemperance
  - Gluttony for:
    - Fats
    - Sweets

    - Addiction to Psychotropics:
        - Stimulants
            - Caffeine, Nicotine
            - Cocaine, Amphetamines
            - Cannabis, Psychedelics
        - Depressants
            - Sedatives: Alcohol, Barbiturates
            - Narcotics (Opiates)
    - Lust
        - Fornication: Adultery, Prostitution
        - Masturbation, Pornography
    - Risk-taking
        - Gambling
- Greed
    - Prodigality
        - Gambling
    - Covetousness
    - Envy
- Malice
    - Sexism, Homophobia
    - Racism, Xenophobia
    - Religious Bigotry

Humans free to engage in vice can seriously harm themselves, as through intemperance or prodigality. Should every competent adult human be free to harm himself through vice, or are some vices so self-detrimental that the state should regulate them? Society and the state should try to use persuasion rather than coercion to discourage vice.

The **Ten Commandments** are the rules of conduct given by Yahweh to Moses in Exodus 20:1-17, prescribing worship of Yahweh and honor for parents while prohibiting killing, adultery, theft, false witness, and covetousness.

Of the Ten Commandments, the first four indicate an insecure god afraid of losing his authority. Only three commandments can be related to sensible legal prohibitions (against murder, theft, and perjury/fraud). The remaining three commandments should in a free society only have the force of good advice.

Evil is either of sadism or injustice. **Sadism** is any person's practice of taking pleasure in another being's unhappiness as an end in itself. Humans are not by nature necessarily sadistic or unjust, but they are, like all known organisms, naturally self-interested. Like being alive, being self-interested is almost always a necessary cause of being unjust, but that makes neither life nor self-interest necessarily evil. Humans, like all known social organisms, are naturally cooperative. Humans are not by nature necessarily evil, but their natural self-interest gives them a natural capacity for evil. In their natural

social environment of family and community, humans tend naturally to be more good than evil, and to cooperate for mutual benefit.

Choosing Human Values

All persons should

- protect personal life and liberty and prevent torture and extinction;
- practice virtue and resist vice; and
- choose and pursue their values.

Humans should value love, family, fellowship, and industry.

Love is strong affection and devotion. Romantic love is deep and intimate affection and devotion involving sensual passion, reproductive desire, and mutual unity of interest. Each human should seek a mate with whom he or she has mutual sensual attraction, shared values, and compatible temperament. Humans should seek a mate by applying a balance of these three criteria, and by balancing short-term pleasure and convenience against long-term happiness. Romantic love is worth making efforts and taking risks, and finding it thus requires wisdom and fortitude. If circumstances preclude finding it, then living happily without it also requires wisdom and fortitude.

Family. Humans should honor the memories of their ancestors. Humans should respect and repay the devotion of their parents. Human siblings and cousins should provide each other fellowship and aid. Humans should have as many children as they can provide with a materially and emotionally sound upbringing. Humans should instill in their children personal virtues and extropian and human values.

Fellowship is the enjoyment of human company through the sharing of ideas, humor, competition, industry, or fun.

Industry is economic, intellectual, or artistic production. Humans should practice industry to provide for their material well-being and to satisfy their appetite for learning and feeling useful. Humans should throughout their lives try to improve their understanding of the foundations and frontiers of human knowledge. Humans should choose careers that balance their personal interests and temperament with occupations of high or increasing economic productivity.

Practicing Human Virtues

Wisdom. Though humans know no easy formula for wisdom, certain practices recommend themselves. A person should seek knowledge, especially knowledge of self and meta-knowledge -- knowledge about one's and others' knowledge. A person should apply the methods of skepticism, positivism, empiricism, and science. A person should identify and question his assumptions, and test his most cherished beliefs against the best criticism of them -- and alternatives to them -- that he can find. For any proposition in question, a person should ask:

- Under what conditions could it possibly be true? Under what conditions could it possibly be false?
- What implications follow from its truth or falsity?
- What are the best arguments and evidence for and against it? Is it verifiable? Is it falsifiable?
- Under what conditions could a person conceivably believe it?

- Who said it? What is their authority and possible motivation?

Perspective is essential for conducting life wisely. For any decision which is (or might seem) important, a person should ask himself:

- What difference will it make in three months, years, decades, and centuries?
- Which decision do I want to remember myself as having made?
- What would I decide if others were observing my deliberations?
- What if everyone made the same decision in such circumstances?

A person should consider what he would want his tombstone and obituary to say. A person should minimize regrets, by balancing the expected outcome of each decision with any future regrets for not making alternative decisions.

Fortitude. Misfortune inflicted by persons should be rebelled against. The cost of rebellion should be weighed against not just the direct benefits but also the opportunity costs to other persons of not rebelling.

Natural misfortune exists for the same reason that natural fortune exists: the universe is neither benevolent nor malevolent. Misfortune inflicted by nature should not be compounded by useless resentment. The misfortunate should seek to evoke in others not co-misery but empathy and appreciation for relative fortune. The unrealized possibility of even worse misfortune should not make the misfortunate happy, but it should make them less unhappy and help them avoid compounding unhappiness. Suicide should only be considered as an alternative to unavoidable and terminal physiological torment.

Misfortune is any harm one experiences, other than injustice, that can be seen as beyond one's control. Some of the dimensions of misfortune are:

- Harm
  - Death
  - Disability
  - Illness, injury
  - Loss, opportunity cost
- Victim
  - Being
  - Nationality
  - Civilization
  - Species
  - Ecosystem
  - Universe
- Relation
  - Self
  - Relative
    - Child, other descendent
    - Parent, other ancestor
    - Sibling, cousin, etc.

    - Mate, in-law, step-relative
    - Associate
- Agency
    - Self
    - Negligence
    - Chance

Fear is natural and healthy, but should be overcome through wisdom when it is not fully warranted. Similarly, wisdom should promote fear when ignorance or impulsiveness prevents it from mounting. Humans generally fear too little for their long-term safety and well-being, and too much for their short-term social repute. (Perhaps this is because the latter determined the former for much of the history of the human species.) Human adults only get around 20,000 days to spend, and any one of them wasted can never be refunded. No day should be pass unused simply for short-term fears, and future days should not be squandered on risk-seeking or revenge. Only for the protection of life and liberty is the risk of heroic self-sacrifice advisable -- and sometimes obligatory.

Temperance. Humans should seek the maximum pleasure for themselves and other beings that is consistent with their fundamental human and personal values. Pleasure, even if natural, should not itself be a fundamental human value, for several reasons.

- Humans for the most part cannot choose what will appeal to their appetites and senses, and so hedonism constitutes surrender of the mind and slavery to the body.
- Single-minded pursuit of sensual pleasure inevitably conflicts with other values.
- Most somatic pleasures require ever-increasing stimulation, probably because nature selects against organisms that can find unlimited pleasure in pursuits other than self-preservation and reproduction. (Intellectual pleasure, such as humor or learning, seems not to require ever-increasing stimulus, if only because it requires *changing* stimulus.)

If pleasure were one's ultimate value, then one would be agreeable to entering an illusory paradise. An **illusory paradise** is an artificial or virtual environment which one believes is real and which is actively and intelligently optimized for one's happiness. For example, in such a paradise one would have all (and only) the success and luck that is consistent with one's need for challenge and achievement. We who value intelligence and life more highly than pleasure would reject an illusory paradise, unless perhaps it were the only alternative to irremediable suffering.

Fairness. Fairness is the most obligatory virtue, for two reasons. First, much of fairness consists in practicing justice, which is itself obligatory. Second, fairness derives directly from the meta-ethical values of universality and impartiality, as is reflected in the Golden Rule. For this reason, fairness is like wisdom a maximal virtue: it is impossible to be too wise or too fair.

Kindness. Kindness is the most sublime of the virtues. Kindness includes being in a good mood and assuming in others the best motive that is consistent with available evidence.

The virtue of kindness makes humans want to help their fellow humans, especially those in need. A common view is that the best form of kindness is charity. **Charity** is the sharing of material wealth with the needy. But throughout history the greatest improvements in human

well-being have come not from charity but from justice and knowledge. Humanity's surplus of injustice, superstition, and ignorance is a far bigger problem than its deficit of charity.

1.3.4. Philosophy / Axiology / Aesthetics

Aesthetics: the study of beauty.

Beauty is the quality of being pleasing to apprehend with the senses or contemplate with the mind.

Origin of Beauty

Beauty can vary in origin:

- Natural beauty can derive from
  - Animate beauty
    - Human beauty is a special case that evolution ensures humans appreciate.
  - Inanimate beauty
  - Environmental beauty
- Artificial beauty can vary by
  - How it is made:
    - Material beauty
    - Performative beauty
    - Conceptual beauty
  - Why it is made:
    - Accidental beauty
    - Intentional beauty

Authenticity is property that obtains when appearance reliably indicates essence, and when the responsible person (if any) has no intent to dissemble. Many humans consider the authenticity of an artifact, and the intentions of its creator, to be important aspects of the object's beauty or lack thereof. For such humans, beauty consists not merely in sensual appeal.

Since the latter decades of the 1900s there seems to be in Western culture an inordinate emphasis on authenticity. People don't ask if the food at a restaurant tastes good; they ask if it is authentic. Reviewers need to know an author's life story before mustering an opinion on her novel. Ideas are judged less on their merits than on the resume of their advocate. This trend seems to reveal that people are not confident enough in their value judgments, and excessively afraid of feeling duped in any way. This seems to be a consequence of the excess relativism that has developed as a reaction to the collapse in the 1900s of old-fashioned absolutisms and hierarchies concerning religion, ethnicity, and gender. Deconstructionismand Critical Theory are two examples of this extreme relativism.

Appeal of Beauty

Beauty can appeal to different faculties:

- Sensual beauty appeals mainly to the senses connected to cognition.

- Visual beauty can derive from color, brightness, form, or their contrasts and changes.
- Auditory beauty can derive from a wide variety of sonic properties.
- Olfactory sensations are sometimes considered by humans to be beautiful, but such sensations are merely gratifying and are not considered an artistic medium.
- Sensations of touch, taste, temperature, and equilibrium are even less often considered beautiful by humans, probably because in humans these senses are less developed and less connected to cognition. Would persons with highly developed senses other than sight and hearing ever consider these other sensations to be beautiful and thus an artistic medium?

- Affective beauty can be of several different kinds.
  - **Sublimity** is the quality of evoking feelings of awe, transcendence, reverence, and humility.
  - **Tragedy** is a circumstance evoking fear, sympathy, and regret for the (perhaps inevitable) misfortune of one or more pitiable persons.
  - **Comedy** is a circumstance involving
    - a shift in perspective or context that is unexpected but still makes sense, or
    - the foiling of someone's intentions, or
    - ridicule of someone (such as oneself).
- Intellectual beauty can derive from properties such as
  - irony or earnestness
  - simplicity or complexity
  - harmony or disunity
  - clarity or ambiguity
  - completeness or incompleteness
  - perfection or imperfection
  - significance or reference (including self-reference)

The presence and nature of perceived beauty in the universe is likely an inevitable result of each perceiver's evolutionary history. Humans find an oak canopy beautiful and a muddy trench ugly, but an intelligent mole rat (lacking H. sapiens' arboreal past) would have the opposite opinion. Thus beauty, like all values, is ultimately subjective, as it depends on the faculties and preferences of the beholder. However, beauty can in defined contexts be objective if there is among the beholders enough commonality of faculty and preference. How different would be the aesthetic preferences of humans and non-human persons with similar faculties?

2. Mathematics

Mathematics: the study of necessary truths about inference, order, quantity, and relation.

1. **Logic**: the study of valid inference.
2. **Set Theory**: the study of sets and the most basic operations on them.
3. **Algebra**: the study of operations on sets of numbers and symbols representing them.
4. **Geometry**: the study of transformations of sets of points in space.
5. **Analysis**: the study of infinite processes as they approach limits.
6. **Combinatorics**: the study of selection and arrangement within finite sets.
7. **Applied Mathematics**: the study of the sampling or processing of information.

Mathematical objects exist only in the axioms and rules that imply them and in the minds that consider them.

Humans have proposed various theories about the nature and basis of mathematics.

- Realism holds that mathematics objects are universals that exist independently from any instance or mind.
- **Logicism** is the thesis that mathematics can be derived from pure logic.
- **Intuitionism** is the thesis that mathematical objects exist only if they can be constructed by a definite procedure, and that the law of the excluded middle cannot be assumed, at least in cases involving infinite sets.
- **Formalism** is the thesis that mathematics can be reduced to a syntactic system that needs only to be proved self-consistent.
- **Social Constructivism** is the thesis that mathematics and science are human social constructions.

Realism is wrong because no mathematical objects can exist independently of the axioms that imply them and the minds that consider them. Social Constructivism and Intuitionism both incorrectly hold that mathematical objects cannot exist implicitly in the axioms that imply them. Formalism fails in its ambition, because a mathematical formalization cannot be both complete and consistent. Logicism is the most satisfactory of these theories, because it recognizes that mathematical objects are implied by the axiomatic systems underlying them.

Why Math Works

Humans sometimes ask why mathematics works so well in describing the universe. First, the universe contains a lot of discreteness, invariance, and continuity, all of which are mathematical subjects.

- Discreteness: celestial bodies, species, organisms, cells, molecules, atoms, quanta, even spatial dimensions;
- Invariance: conserved quantities like mass-energy, momentum, and electric charge; unchanging constants like the speed of light and the strengths of the physical forces;
- Continuous regularities, as reflected in the mathematical structure of so many physical laws.

Second, mathematics is defined and designed to be nothing other than the study of the truths that are

the demonstrably necessary consequences of *any* system of quantity, relation, and inference itself. So it is unsurprising and natural that mathematics describes the physical universe so well. Note that, like science, mathematics does not describe the social (i.e. volitional) universe nearly so well, and for the same reasons.

History of Math

Some of the discoveries or inventions of fundamental mathematical concepts and problems are:

- c500BC Irrational numbers are discovered in Greece.
- c300BC Axiomatization and proof become well-developed in Greece.
- c800 Zero is invented in India as a number for use a base-10 positional number system.
- 1665 Calculus is invented by Newton (and independently by Leibniz) to understand infinite processes as they approach limits.
- 1744 Transcendental numbers are shown to exist by Euler.
- 1790s Complex numbers are discovered.
- 1820s Non-euclidean geometry is invented by questioning Euclid's parallel postulate.
- 1879 Mathematical logic is formalized by Frege after earlier work by Boole.
- 1895 Transfinite numbers are discovered by Cantor.
- 1902 Russell discovers the self-referential Russell Paradox in Frege's formalization.
- 1908 Set theory is axiomatized by Zermelo.
- 1931 Godel proves that mathematical formalizations are necessarily incomplete.

2.1. Mathematics / Logic

Logic: the study of valid inference.

1. **Formal Logic**: the study of systems of valid inference.
2. **Metalogic**: the study of valid inference about systems of valid inference.
3. **Applied Logic**: the application of logic to special arenas of inference .

Inference is the process of deriving a new proposition (the conclusion) from a given set of propositions (the premises). There are two forms of inference:

- **Deduction** is the process of deriving a conclusion that is necessarily true if its premises are true.
- **Induction** is the process of deriving from particular premises a general conclusion that is probably true.

Because induction is uncertain and depends so much on the specific nature of the premises, the topic of logic focuses almost exclusively on deduction and leaves induction to science.

2.1.1. Mathematics / Logic / Formal Logic

Formal Logic: the study of systems of valid inference.

Propositional Calculus

Propositional Calculus is a system of valid inference about propositions and operations on them.
A **proposition** is a definite expression about particular terms that is either true or false. Each operator of Propositional Calculus yields a proposition.

- Unary Operators
  - Negation (not). $\neg p$ is true if and only if p is false.
- Symmetrical Binary Operators yield the same truth-value when the operands are transposed:
  - Conjunction (and). $p \cdot q$ is true if and only if p is true and q is true.
  - Disjunction (or). $p \vee q$ is true if and only if $\neg(\neg p \cdot \neg q)$
  - Nonconjunction (nand). $p \otimes q$ is true if and only if $\neg(p \cdot q)$
  - Nondisjunction (nor). $p \oplus q$ is true if and only if $\neg p \cdot \neg q$
  - Equivalence (xnor). $p \equiv q$ is true if and only if $\neg(\neg(p \cdot q) \cdot \neg(\neg p \cdot \neg q))$
  - Difference (xor). $\neg(p \equiv q)$ is true if and only if $\neg(p \cdot q) \cdot \neg(\neg p \cdot \neg q)$
- Asymmetric Binary Operators may not yield the same truth-value when the operands are transposed:
  - Implication. $p \rightarrow q$ is true if and only if $\neg(p \cdot \neg q)$

All of the operators can be defined using only

- negation and conjunction (as shown above);
- negation and disjunction;
- negation and implication;
- nonconjunction (where $\neg p$ is defined as $p \otimes p$); or
- nondisjunction (where $\neg p$ is defined as $p \oplus p$).

Axiomatization. An axiomatization of propositional calculus consists of some well-formed formulae designated as axioms, and transformation rules for deriving valid formulae (called theorems) from them. One axiomatization of propositional calculus by Russell and Whitehead includes

- Primitives: $\neg \vee ( )$ and propositional variables
- Formation rules stating that a well-formed formula (wff) is
  - any single propositional variable
  - $\neg\alpha$, (α), and $\alpha \vee \beta$ are wff if α and β are
- Definitions of $\cdot \rightarrow \equiv$
- Axioms
  - $(p \vee p) \rightarrow p$
  - $q \rightarrow (p \vee q)$
  - $(p \vee q) \rightarrow (q \vee p)$
  - $(q \rightarrow r) \rightarrow ((p \vee q) \rightarrow (p \vee r))$
- Transformation rules:
  - Substitution: uniformly replacing any variable in a theorem with a wff yields another theorem
  - Modus Ponens: if α and $(\alpha \rightarrow \beta)$ are theorems, then β is a theorem

Theorems. Important theorems of propositional calculus are:

- Equivalence of identity: $p \equiv p$
- Double negation: $p \equiv \neg\neg p$
- Excluded middle: $p \vee \neg p$

- Noncontradiction: ¬(p · ¬p)

Predicate Calculus

Predicate Calculus is a system of valid inference about propositions, their constituent terms, predicates and quantifiers, and operations on them. A **term** is a reference to that which can be considered as separate and distinct or counted as one, such as a person, place, instant, action, idea, or proposition. A **predicate** is an expression of one or more terms drawn from one or more sets denoting the membership of their permutation in a subset of the cross-product of those sets and connoting that permutation's enjoyment of the attribute associated with that subset. A **property** is any one-term predicate such as Red(). A **relation** is any multiple-term predicate such as Loves(,). A **variable** is a symbol that stands for a term or predicate. A **quantifier** is an expression that, for a variable term in a specified proposition, tells how many definite terms (e.g. all, some) it applies to.

- Universal Quantifier: ∀x means "for all x".
- Existential Quantifier: ∃x means "for at least one x".

Each of the two quantifiers may be defined in terms of the other. **First-Order Predicate Calculus** is the subset of Predicate Calculus in which no predicate variable is quantified. The First-Order Predicate Calculus is not decidable, but becomes so if predicate variables are restricted to being unary.

A binary relation R over a a set's cross-product with itself may enjoy various attributes:

- Reflexive: (∀x) R(x,x) e.g. "is identical to"
- Irreflexive: (∀x) ¬R(x,x) e.g. "is younger than"
- Quasi-reflexive: (∀x)((∃y)R(x,y) → R(x,x)) e.g. "has same hair color as" (vs. bald)
- Nonreflexive: ((∃x)R(x,x)) · ((∃x)¬R(x,x)) e.g. "is proud of"
- Symmetric: (∀x)(∀y)(R(x,y) → R(y,x)) e.g. "is related to"
- Asymmetric: (∀x)(∀y)(R(x,y) → ¬R(y,x)) e.g. "is the child of"
- Nonsymmetric: ((∃x)(∃y)(R(x,y) · R(y,x))) · ((∃x)(∃y)(R(x,y) · ¬R(y,x))) e.g. "likes being related to"
- Transitive: (∀x)(∀y)(∀z)((R(x,y) · R(y,z)) → R(x,z)) e.g. "is ancestor of"
- Inransitive: (∀x)(∀y)(∀z)((R(x,y) · R(y,z)) → ¬R(x,z)) e.g. "is mother of"
- Nontransitive: ((∃x)(∃y)(∃z)((R(x,y) · R(y,z) · R(x,z))) · ((∃x)(∃y)(∃z)((R(x,y) · R(y,z) · ¬R(x,z))) e.g. "is stepsibling of"
- Equivalence: any relation that is reflexive, symmetric, and transitive, e.g. "is related to"

Identity. First-Order Predicate Calculus can be extended with the two-term predicate identity (=). This predicate allows quantification to express precise numerical bounds, by saying that two variables must or must not identify the same instance. A proposition can contain what appears to be a term but that refers to no existing thing, such as "the present king of France". Such a phrase is not a term but a definite description. A **definite description** is an expression that appears to simply refer to some thing but instead actually makes a claim that the uniquely described thing exists.

Is. There are at least four logical meanings of 'is':

- Existence: "Earth is" or "(∃x)(x = Earth)". Hence Quine's dictum that to be is to be the value of a bound variable.
- Identity: "Earth is our planet" or "Earth = our planet"

- Predication: "Earth is a planet" or "Planet(Earth)"
- Implication: "A planet is a world" or "(∀x)(Planet(x) → World(x))"

Second-Order Predicate Calculus is the subset of Predicate Calculus in which both term variables and predicate variables may be quantified. Second-Order Predicate Calculus can use Leibniz's Principle of the Identity of Indiscernibles to define x = y as (∀φ)(φx≡φy): "for all possible predicates, the predicate applies to x as it applies to y".

Modal Logic

Modal Logic is a system of propositional logic that adds operators concerning necessity and possibility. Modal Logic adds to Propositional Calculus the following:

- modal operators
  - Necessity: Lα is true if and only if it is necessary that α is true.
  - Possibility: Mα is true if and only if ~L~a (it is not necessary that α is not false).
- axioms
  - Lp → p
  - L(p → q) → (Lp → Lq)
- transformation rule
  - If α is a theorem, so is Lα (i.e. theorems are necessarily true).

Stronger systems of modal logic (named S4, S5, and Brouwerian) can be obtained by adding axioms that the modality of a proposition is itself a necessary modal truth. S4 results by adding the axiom Lp → LLp. S5 results by adding Mp → LMp. The Brouwerian system results by adding p → LMp. These modal propositional calculi are decidable, but modal first-order predicate calculi are not.

Other Logics

Many-Valued Logic. Some philosophers assert that propositions about future or non-existent things can be neither true nor false. For example, "there will be a sea battle tomorrow", or "the present king of France is bald". Propositional calculi can be defined in which there is a third truth-value (e.g. neuter, half-true) or even infinitely many gradations of truth-value. In such a propositional calculus the laws of noncontradiction and the excluded middle do not hold. Fuzzy Logic is a sort of many-valued logic in which truth or set membership is expressed as a probability rather than as all-or-nothing.

Intuitionist Logic. Intuitionism rejects the validity of the laws of the excluded middle and of double-negation, and thus any reductio ad absurdam argument. Intuitionism rejects the use of truth tables for testing the validity of propositions, because truth tables assume one can exclude "middle" possibilities of neither truth nor falsity.

2.1.2. Mathematics / Logic / Metalogic

Metalogic: the study of valid inference about systems of valid inference.

The **decidability** of a system of logic is the property of having an effective or mechanical procedure for deciding the truth value of any well-formed formula of the system.

A system is **consistent** if ¬α is not a theorem whenever α is a theorem. A system is **weakly complete** if every valid wff is a theorem. A system is **strongly complete** if the addition as an axiom of any wff not already a theorem would make the system inconsistent. An axiom or transformation rule of a system is **independent** if it cannot be derived from the remainder of the system's axiomatization. The

propositional calculus is decidable, consistent and strongly complete, and each of its axioms and transformation rules are independent. The first-order predicate calculus is undecidable, consistent and at least weakly complete.

Godel's 1st Incompleteness Theorem states that all consistent systems of number theory include undecidable propositions. **Godel's 2nd Incompleteness Theorem** states that no consistent system of number theory can prove its own consistency.

2.1.3. Mathematics / Logic / Applied Logic

Applied Logic: the application of logic to special arenas of inference .

Fallacies

A **fallacy** is any potentially persuasive argument that is not a valid method of inference.

- **Material fallacies** are fallacies that misuse facts.
  - The **fallacy of accident** is applying a general truth to a particular proposition which violates the general truth's tacit qualifications. The **converse fallacy of accident** is improper generalization from anecdotal evidence.
  - The **fallacy of false cause** is assuming that temporal coincidence or succession demonstrates a causal relationship.
  - A **red herring** is attempting demonstrate something other than what is at issue.
  - A **fallacy of irrelevance** is using irrelevant facts to support a position.
    - The **genetic fallacy** is asserting a truth based on facts about those who affirm or deny it.
    - **Ad ignorantium** is asserting a truth based on an absence of knowledge of its falsehood.
    - A **straw man** is an attack on an argument different from the opposing argument.
  - **Circular reasoning** (question begging) is using premises which assume the conclusion.
  - The **fallacy of presupposition** is embedding a false premise in a question or statement.
- **Verbal fallacies** are fallacies that misuse words to produce ambiguity.
  - **Equivocation** is using different meanings for the same word(s).
- **Formal fallacies** are fallacies that misuse deduction.
  - **Non sequitor** is the assertion of a conclusion logically unrelated to the given premises.
  - **Affirmation of the consequent** is the assertion that $(A \rightarrow B)$ and (B) implies (A).
  - **Denial of the antecedent** is the assertion that $(A \rightarrow B)$ and $(\neg A)$ implies $(\neg B)$.
  - The **fallacy of the undistributed middle** is the assertion that (all A are Z) and (b is Z) implies (b is an A).
  - The **fallacy of the excluded middle** is the assertion that $(\neg A)$ implies (Z) when (A or Z) is not true.

Paradoxes

A **paradox** is a statement or conclusion that seems false or contradictory but actually might be true.

- A **sorites paradox** reaches an absurd conclusion by repeatedly applying to a reasonable base case a seemingly reasonable absolute rule that is in fact slightly unreasonable. Example: if (a) 1 is a small number and (b) 1 plus any small number is another small number, then all numbers are

small. In fact, the second premise is not strictly true. Variants of this paradox involve predicates like poor, bald, and not-a-heap.

  - **Lottery paradox**: if (a) it is reasonable to believe that any given lottery ticket is not a winner and (b) the lottery can only be won by a winning ticket, then it is reasonable to believe that the lottery will not be won. Here, (a) is not strictly true. It is not reasonable to believe that any given lottery ticket is not -- i.e. cannot be -- a winner. Any weaker belief is consistent with the lottery having a winning ticket.
  - **Paradox of identity** (or of Theseus' ship): if replacing one component of a composite entity does not change its identity, then the entity can share identity with a later composite having no common components, and can not share identity with a later composite consisting entirely of its original components. This is not a true sorites paradox, because the conclusion only seems absurd to those who do not fully understand identity.

- A **self-reference paradox** creates indeterminacy or contradiction through self-reference.
  - The **liar paradox** (or **Eubulides Paradox**) is "this statement is false". (**Epimenides' paradox** is the statement by Epimenides that all Cretans are liars because one has said so, and is not really a paradox because the existence of one honest Cretan makes it just a falsehood.) Godel's Incompleteness Theorems rest on a mathematization of the liar paradox.
  - **Russell's paradox**, discovered in May 1901 by Bertrand Russell, points out that the set of all sets that are not members of themselves is a member of itself if and only if it is not a member of itself. Since mathematics is based on set theory, any mathematical proof is suspect if set theory allows this contradiction. Modern set theory avoids the paradox by restricting the kinds of predicates (like not-members-of-themselves) that can be used to define sets. Variants of this paradox include the Barber Paradox and the Catalog Paradox.
  - **Grelling's paradox** is that the adjective 'heterological', meaning 'not self-applicable', is itself heterological if and only if it is not heterological.
  - The **Berry Paradox** refers to "the smallest number not describable in less than eleven words", and thus purports to describe that number in less than eleven words.
  - The **omniscience paradox** attempts to show omniscience (knowing every true sentence) is impossible because "no being knows this sentence is true" is a true sentence that no omniscient being could know.
  - The **omnipotence paradox** attempts to show omnipotence (able to create anything and control anything) is impossible because something uncontrollable is a thing no omnipotent being could create.
  - The **unexpected event** (hanging, exam) is one that will happen to a person in in the next N days on a day that person doesn't expect, and seems paradoxical because the person can seemingly prove that the event cannot be on the last day or (by iterative reasoning) any previous day. But proving the event cannot happen then allows it to be unexpected, and thus this paradox is equivalent to the statement "you cannot prove this statement is true".
- An **infinity paradox** is a paradox built on the counter-intuitive nature of infinity.
  - **Zeno's paradoxes** attempt to deny the reality of motion by deriving absurd conclusions from a misunderstanding of how infinitesimals interact with limits.
  - **Hilbert's hotel paradox** shows that a hotel of infinitely many rooms and no vacancies can nevertheless accommodate infinitely many more guests (because $\infty + \infty = \infty$).
  - The **Thompson Lamp Paradox** asks whether a lamp will be on or not at one minute if it

is turned on for 1/2 minute, off for 1/4 minute, on for 1/8 minute, etc., and is equivalent to positing a "last" integer.

- *Paradoxes of Game Theory*
  - **Newcomb's Paradox**, invented by William Newcomb, is the choice of one or both of two prizes, the first of which is of a modest known value, and the second of which is worth either nothing or a fortune, depending on whether a heretofore infallible seer predicted both prizes would be chosen. The right choice depends simply on whether one believes one's choice can influence or be foreseen by the seer's earlier prediction. The former belief implies a causal loop, and the latter implies some form of determinism, both of which are counterintuitive and thus clash with the seer's empirical infallibility.
  - The **St. Petersburg paradox**, invented by Daniel Bernoulli (1700-1782), is that there is infinite expected value from a game with infinitely many possible consequences where the reward from each consequence is the reciprocal of its probability. This absurd result rests on the false premises that unlimited wealth is available to fund rewards and that unlimited value or utility is even possible.
  - The **Two-Envelope Paradox** asserts that, for two envelopes with a 2:1 ratio of money hidden inside them, the expected value of picking the other envelope is always 25% higher. This paradox disappears if there is any finite maximum value for how much an envelope might contain.
  - The **Prisoner's Dilemma**, formulated by Albert Tucker, is a non-zero-sum two-player game in which both players would do better if they both cooperated rather than not, but each can always improve his outcome by not cooperating, and so rational self-interest leads to a suboptimal outcome. This counter-intuitive suboptimality is eliminated if the players believe they will be engaging in repeated interactions in which they can recognize each other and remember each other's past behavior.
- *Paradoxes of Inductive Prediction*
  - **Hempel's Paradox**, discovered by Carl Hempel in 1965, is that if a statement ("all ravens are black") tends to be confirmed inductively by observations ("yet another black raven"), then it should also tend to be confirmed by observations ("yet another non-black non-raven") that confirm its (logically equivalent) contrapositive ("all non-black things are non-ravens"). "Yet another non-black non-raven" does indeed tend infinitessimally to confirm "all ravens are black" -- or, more precisely, the infinite disjunction "(all ravens are black) or (all ravens are white) or ..".
  - **Grue**, described by Nelson Goodman (1906-1998), is the color predicated of anything appearing green when first observed before a future time T, or blue when first observed after time T. **Goodman's Paradox** is that all observations supporting "emeralds are green" also support "emeralds are grue". Goodman's Paradox is resolved by noting that "emeralds are green" represents a more parsimonious explanatory scheme than does "emeralds are grue".
  - Doomsday Argument

Mereology

Mereology is the study of part-whole relationships. Mereology helps to resolve Russell's Paradox concerning the set of all sets not containing themselves. It does so by disambiguating the distributive and collective interpretations of "e is an element of the set of M's". The distributive (i.e. predicative) interpretation is "e is an M", while the collective interpretation is "e is a part of the whole consisting of all the M's".

The fundamental definitions of mereology are:

- **Inclusion** (I) is the fundamental relation of mereology and is not formally defined, but it is to be understood that (**a** I **b**) if and only if **b** is a part of **a** or is the same object as **a**.
- **Disjointness** (|): **a** | **b** is true if and only if $\neg(\exists \mathbf{x})((\mathbf{a}\ \mathrm{I}\ \mathbf{x}) \cdot (\mathbf{b}\ \mathrm{I}\ \mathbf{x}))$.
- **Comprising** ($\sum$): **S** $\sum$**b** is true for a set **S** if and only if $(\forall \mathbf{x})(\ \mathbf{x}|\mathbf{b} \equiv (\forall \mathbf{y})(\mathbf{y} \in \mathbf{S} \rightarrow \mathbf{y}|\mathbf{x}))$.

The fundamental axioms of mereology are:

- Things that are part of each other are identical:
  - $(\forall \mathbf{x})(\forall \mathbf{y})((\mathbf{x}\mathrm{I}\mathbf{y} \cdot \mathbf{y}\mathrm{I}\mathbf{x}) \rightarrow (\mathbf{x}=\mathbf{y}))$
- A thing is part of a whole only if everything that is disjoint from the whole is disjoint from the part:
  - $(\forall \mathbf{x})(\forall \mathbf{y})(\mathbf{x}\mathrm{I}\mathbf{y} \equiv (\forall \mathbf{z})(\mathbf{z}|\mathbf{x} \rightarrow \mathbf{z}|\mathbf{y}))$
- Every non-empty set comprises some sum:
  - $(\exists \mathbf{x})(\mathbf{x} \in \mathbf{S}) \rightarrow (\exists \mathbf{y})(\mathbf{S} \sum \mathbf{y})$

2.2. Mathematics / Set Theory

Set Theory: the study of sets and the most basic operations on them.

A **set** is a formally undefined notion in set theory that can intuitively be understood as a collection of terms. **Membership** ($\in$) is a formally undefined relation in set theory that can intuitively be understood as "being an element of", and is such that a given object either is or isn't a member of a given set.

Axiomatization.

Zermelo-Fraenkel Set Theory is the standard axiomatization of set theory, and when combined with the axiom of choice is designated ZFC. The axioms of ZFC are:

- **Extension**. Two sets are identical if and only if they have the same members.
- **Empty set**. There exists a set with no members: the empty set.
- **Separation**. For any set S and condition C, there exists a set S' containing all and only the members of S satisfying C provided that C does not quantify over S'.
- **Pairing**. For any two sets, there exists a set having those two sets as its only members.
- **Power Set**. For any set S, there exists a set P whose members are all and only the subsets of S.
- **Union**. For any set S, there exists a set U whose members are all and only the members of the sets that are members of S.
- **Infinity**. There exists a set S having the empty set as a member and, if x is a member of S, then so is $\{x, \{x\}\}$.
- **Well-Ordering**. For every set there exists a total order such that every non-empty subset of S has a least member under that order.

The **axiom of choice** states that for any set S of non-empty sets, there exists a function F defined on S such that for each member X of S, F(X) is (i.e. chooses) a member of X. The axiom of choice is equivalent to the well-ordering axiom, in that each can be used with ZF to prove the other.

type theory, classes, category theory, topos theory

operations on, relations on,

Relations and functions can be defined as sets of ordered pairs, and thus can be defined strictly within set theory.
The Babylonian sexagesimal (base-60) numeric system is the basis of the modern measures of time and angles.

The **continuum hypothesis** is that there is no set with cardinality greater than the set of natural numbers but less than the set of its subsets. The continuum hypothesis can be neither proved nor disproved by the axioms of ZFC.

2.3. Mathematics / Algebra

Algebra: the study of operations on sets of numbers and symbols representing them.

1. **Arithmetic**.
2. **Number Theory**.

2.4. Mathematics / Geometry

Geometry: the study of transformations of sets of points in space.

1. **Euclidean Geometry**.
2. **Non-Euclidean Geometry**.
3. **Topology**: the study of invariance under non-discontinuous geometric deformation.

2.4.1. Mathematics / Geometry / Euclidean Geometry

2.4.2. Mathematics / Geometry / Non-Euclidean Geometry

2.4.3. Mathematics / Geometry / Topology

Topology: the study of invariance under non-discontinuous geometric deformation.

2.5. Mathematics / Analysis

Analysis: the study of infinite processes as they approach limits.

1. **Differential Calculus**.
2. **Integral Calculus**.
3. **Vector Analysis**.

2.6. Mathematics / Combinatorics

Combinatorics: the study of selection and arrangement within finite sets.

2.7. Mathematics / Applied Mathematics

Applied Mathematics: the study of the sampling or processing of information.

1. **Information Theory**.
2. **Statistics**: the study of the samples and their representativeness.
3. **Optimization Theory**: the study of increasing a valued quantity in a constrained system.
4. **Computer Science**.

2.7.1. Mathematics / Applied Mathematics / Information Theory

2.7.2. Mathematics / Applied Mathematics / Statistics

Statistics: the study of the samples and their representativeness.

2.7.3. Mathematics / Applied Mathematics / Optimization Theory

Optimization Theory: the study of increasing a valued quantity in a constrained system.

2.7.4. Mathematics / Applied Mathematics / Computer Science

3. Natural Science

Natural Science: the study of the regular behavior of nature.

1. **Physics**: the study of matter and energy.
2. **Astronomy**: the study of extraplanetary space and its contents.
3. **Chemistry**: the study of substances and their properties.
4. **Geoscience**: the study of the physical composition and behavior of planets.
5. **Biology**: the study of life.

3.1. Natural Science / Physics

Physics: the study of matter and energy.

1. **Mechanics**: the study of the motion of matter.
2. **Wave Physics**: the study of the motion of disturbances.
3. **Thermodynamics**: the study of heat and its relationship to energy.
4. **Electromagnetics**: the study of the behavior of electromagnetic charge.
5. **Quantum Physics**: the study of the smallest amounts of matter and radiation.

The universe consists ultimately of nothing but elementary particles interacting in space-time via fundamental forces.

Elementary Particles

An **elementary particle** is a quantum of matter or energy that has no known structure or spatial extent and that is subject to one or more of the fundamental forces according to its fundamental properties. Elementary particles can be divided into three generations of increasing relative mass. An **antiparticle** of a particle is one identical to it (e.g. in mass) except for having negated values of quantized properties like electric charge (and thus magnetic moment). Every charged elementary particle has an antiparticle. **Antimatter** is matter composed of the antiparticles of the particles in ordinary matter.

- **Quarks** are fermions that are always bound into hadrons (such as protons and neutrons) and that possess mass, electric charge of 1/3 or -2/3, angular momentum of 1/2, baryon number of 1/3, strong color, and strong flavor.
- **Leptons** are fermions such as electrons and neutrinos that possess mass, electric charge of -1, 0, or 1, angular momentum of 1/2, and lepton number of 1 or -1.
    - **Electrons** are nearly massless stable leptons that carry the smallest independent unit of negative electric charge and that form the shell that gives ordinary atoms their spatial and electrochemical properties. **Positrons** are the positively-charged antiparticles of electrons.
    - **Muons** are leptons similar to electrons and positrons except that they are about 207 times more massive and are subject to decay via the weak force.
    - **Taus** are leptons similar to muons except they are even more massive and more unstable.
    - **Neutrinos** are stable leptons with no electric charge and little or no mass that are generated by nuclear reactions and that can penetrate ordinary matter indefinitely because they feel only gravity and the weak force. There are three generations of neutrinos, corresponding respectively to electrons, muons, and taus.
- **Gauge bosons** are bosons that mediate the fundamental forces. Bosons with odd spin mediate vector fields like electromagnetism that can be either attractive or repulsive. Bosons with even spin mediate vector fields like gravity that are only attractive. Bosons with no spin mediate scalar fields like the hypothetical Higgs field.
    - **Photons** are uncharged massless spin=1 quanta of electromagnetic radiation (such as visible light) that always move at light speed and with a characteristic frequency that determines their color.
    - **Gluons** are uncharged spin=1 strongly-colored carriers of the strong nuclear force.
    - **W-bosons** are relatively massive charged spin=1 carriers of the weak nuclear force.
    - **Z-bosons** are relatively massive uncharged spin=1 carriers of the weak nuclear force.
    - **Gravitons** are hypothetical uncharged massless spin=±2 carriers of gravity.
    - **Higgs bosons** are hypothetical uncharged massless spin=0 bosons that mediate the hypothetical scalar field that gives particles their mass.

Theories beyond the Standard Model predict various new particles such as leptoquark bosons, sleptons, sneutrinos, squarks, selectrons, photinos, gluinos, charginos, neutralinos, axions, and magnetic monopoles.

Fundamental Properties

A **fundamental property** is a way that one elementary particle can differ from another. All other material properties, such as color, temperature, texture, and wetness are composite properties that do not apply to elementary particles.

- **Position** is location in space-time.

- **Rest mass** is the mass a particle would have if not in motion.
- Frequency
- Linear momentum

A **quantized property** is one that can only occur in discrete amounts that are either integral or an integral fraction of 2 or 3. The remaining fundamental properties are quantized.

- Angular momentum or spin of fundamental particles is quantized as multiples of Planck's Constant divided by 2π.
- **Electric charge** is the quantized property that causes matter to be attracted or repelled by electrons.
- **Strong color** is the property of quarks that binds them together.

Other quantized properties serve only as "quantum numbers" that distinguish different particles and govern their conservation and combination.

- **Strong isotopic spin** is the property of nucleons that distinguishes protons (with spin 1/2) from neutrons (with spin -1/2) and that is conserved in strong force interactions.
- **Weak isotopic spin** is the property that distinguishes up and down quarks, or electrons and electron-neutrinos.
- **Strong flavor** is the property that distinguishes the six different types of quarks.
- **Baryon number** is a property of quarks that governs how they may combine into hadrons.
- **Lepton number** is the property of leptons that governs how they are conserved.

Fundamental Forces

All interactions involving matter or energy are due to some combination of fundamental forces.
A **fundamental force** is a force that is not known to be reducible to other forces. Humans know three fundamental forces.

- **Gravity** is the curvature of four-dimensional space-time that causes all masses to attract each other and that is caused by the presence of mass itself. Gravity is the weakest of the fundamental forces but has the most noticeable long-range effects. Gravity holds galaxies, star systems, stars, and planets together. Gravity causes the pressure that ignites stars like the Sun. Gravity causes objects to fall toward Earth instead of drifting away into space.
- The **Electroweak Force** is the unified force that manifests itself as electromagnetism and the weak nuclear force.
    - **Electromagnetism** is the force that is caused by electric charge, that radiates at the speed of light for all observers, and that manifests itself as electric and magnetic forces. Electromagnetism causes the familiar forms of radiation such as visible light, infrared radiation (radiated heat), microwaves, radio waves, and X-rays. Electromagnetism causes materials to absorb, emit, or reflect radiation instead of being transparent to it.
        - **Electricity** is the aspect of electromagnetism that consists of attractive and repulsive Coulomb forces between electric charges that occur as discrete quanta carried by elementary particles. Electricity is far stronger than gravity, but rarely acts over visible distances because positive and negative electrical charge is evenly distributed in the macroscopic world. Electrical repulsion between the electrons in atoms causes short-range contact forces between them and prevents objects from passing through each other. Electrical attraction between an atom's nucleus and the

outer electrons of neighboring atoms is responsible for all chemical properties and reactions.

        - **Magnetism** is the aspect of electromagnetism that consists of attractive and repulsive forces between electric charges that are rotating or otherwise moving in a loop. Magnetism causes magnets to attract certain metals and to attract and repel each other. Magnets are used in compasses and many other devices.
    - The **Weak Nuclear Force** is the short-range force that acts on all fermions and is responsible for the radioactive decay of many kinds of subatomic particles. The weak nuclear force causes the radioactivity that heats the Earth's core and results in geothermal phenomena like volcanism.
- The **Strong Nuclear Force** is the immensely powerful short-range force that causes attraction both among the quarks within hadrons and among the quarks in adjacent hadrons. The strong force overcomes the electrostatic repulsion among protons and binds them together with neutrons in atomic nuclei. Since the strong force is only about 100 times stronger than electromagnetism, nuclei become unstable as they approach having 100 protons. Strong attraction causes the fusion of nuclei lighter than iron that powers thermonuclear explosives and stars like the Sun.

Unification. Human physicists strongly suspect that all three of these forces are merely different manifestations of a single underlying unified force, just as the electric and magnetic forces are different manifestations of the electromagnetic force. How can the fundamental forces be unified into a theory of a single underlying unified force? This is one of the most important unanswered questions in physics.

Conserved Quantities

Conservation is an invariance that holds over time in a system that is closed or isolated in some specified way. **Noether's Theorem** states that every conservation law is associated with some symmetry or homogeneity.

- *Energy-Momentum*
  The "stress-energy tensor" of general relativity is invariant due to the homogeneity of space-time.
    - *Energy* is conserved due to the homogeneity of time.
    - *Momentum* is conserved due to the homogeneity of space.
        - *Linear Momentum* is conserved due to invariance under displacement.
        - *Angular Momentum* is conserved due to invariance under rotation.
- *Charge-Parity-Time* is conserved, so that if a given process is possible, then so is a process with reversed charge, reversed parity (handedness), and reversed temporal direction.
- *Electric Charge* is conserved due to "gauge invariance under an arbitrary phase transformation on a particle wave function".
- *Baryon-Lepton Number*. Baryon and lepton number are each conserved under most interactions, but both are predicted not to be conserved in proton decay. However, the difference of baryon number minus lepton number is predicted to be conserved.

Conservation of baryon-lepton number is predicted to be violated by black holes as they absorb baryons and leptons and evaporate into photons.

Fundamental Constants

Fundamental constants are those in any minimal set of constants each of whose value could not in principle be calculated from the others and the initial conditions of the universe. Fundamental constants include dimension-measuring constants and dimensionless constants.

Dimension-measuring constants are those fundamental constants that help define natural units of measure that are independent of any particular system of measures. These constants define natural units of duration, distance, mass, and electric charge.

- **Speed of Light** (**c** = exactly 299792458 m/s for all observers) in a vacuum relates space to time in the space-time described by relativity. The speed of light defines the rate at which information and influence can travel.
- **Planck's Constant** (**h** = 6.62606876 × 10^{-34} joules·sec) relates the energy of a photon to its frequency and defines the granularity of action in quantum theory. Planck's Constant defines the scale at which the universe is quantized. A related constant is $\underline{\mathbf{h}} = \mathbf{h}/2\pi$.
- **Gravitational Constant** (**G** = 6.673 × 10^{-19} m3/kg·s) relates mass to acceleration and thus defines the strength of gravity.
- **Electron Charge** (**e** = 1.602176462 × 10^{-19} Coulomb) is the natural unit of electric charge.

Dimensionless constants are ratios between quantities of the same dimension that thus have the same value in every system of measures. Humans know of 18 to 22 fundamental dimensionless constants.

- The **Strong Coupling Constant** ($\alpha_s = \mathbf{g_s}^2/\underline{\mathbf{hc}} \approx 1$) defines the strength of the strong nuclear force.
- The **Electroweak Coupling Constant** ($\mathbf{G_F}$) defines the strength of the electroweak force. From it are derived two related dimensionless constants:
  - **Electromagnetic Coupling Constant** or **Fine Structure Constant** ($\alpha_e = \mathbf{e}^2/\underline{\mathbf{hc}} \approx 1/137$) defines the strength of electromagnetism.
  - **Weak Coupling Constant** ($\alpha_w = \mathbf{g_F} m^2\mathbf{c}/\underline{\mathbf{h}}^3 \approx 10^{-5}$) defines the strength of the weak nuclear force, where $\mathbf{g_F}$ is the **Fermi Coupling Constant** ($\mathbf{g_F} = \mathbf{G_F}/(\underline{\mathbf{h}}\mathbf{c})^3 = 1.16637 \times 10^{-5}$ GeV^{-2}) .
- 4 constants that constrain the "3x3 Cabbibo-Kobayashi-Maskawa matrix" that governs how quarks can interact with W bosons.
- [4 new constants of the Maki-Nakagawa-Sakata matrix related to neutrino oscillation]
- Rest masses of the 6 quarks, the 3 charged leptons, and the W, Z, and Higgs bosons, expressed as multiples of the Planck mass.
- Rest masses of the 3 neutrinos (if those rest masses are non-zero).
- The **Cosmological constant** (λ) is a measure of the possibly nonzero energy density of the vacuum.

Mysteries

Why did the Big Bang happen? How can we explain the existence and values of the free variables? Why are there precisely three spatial dimensions? Does the information destroyed in black holes constitute an arrow of time? Is time travel physically possible, perhaps only if paradoxes are censored?

How can Quantum Theory and Relativity be reconciled? Is Quantum Theory correct in requiring either anti-relativistic faster-than-light influence or time-reversed causality? How do black holes destroy

information (other than that of mass, charge, angular momentum, and temperature) that Quantum Theory says must be preserved?

How does sound cause in liquids the generation of small but intense bursts of light and heat known as sonoluminescence? What causes high-temperature superconductivity?

3.1.1. Natural Science / Physics / Mechanics

Mechanics: the study of the motion of matter.

1. **Rigid Mechanics**: the study of the motion of rigid bodies.
2. **Non-Rigid Mechanics**: the study of the motion of non-rigid (elastic and fluid) bodies.
3. **Relativity**: the study of gravity and frames of reference.

Fundamental Concepts

Mechanics has three fundamental concepts:

- Time is the ordering of eventsaccording to the potential of some events to causally influence other events.
- Space is the seemingly boundless and continuous three-dimensional extent in which all matter is located and all events occur.
- **Inertia** is resistance to change in velocity.

Each concept has an associated quantity:

- Duration (**t**) is a measure of the separation between two instants in time.
- **Distance** (**d**) is a measure of the separation between two points in space.
- **Mass** (**m**) is a measure of inertia.

Each quantity has a standard unit of measure:

- A **second** is the duration required for 9,192,631,770 wave periods of a particular emission of cesium-133. Before 1967, a second was defined as a fraction of the length of the year 1900 as measured by stellar motion. Before 1956, a second was defined as 1/(24*60*60) of the mean solar day.
- A **meter** is the distance light travels through a vacuum in 1/299,792,458 sec. Earlier, a meter was defined as the distance between two marks on a platinum-iridium bar kept in Sèvres, France, near Paris. Originally, a meter had been defined as 1/40,000,000 of the earth's polar diameter.
- A **kilogram** is the mass of the International Prototype Kilogram, a platinum-iridium cylinder kept at Sèvres, France, near Paris. Originally, the kilogram had been defined as the mass of 1000 cubic centimeters of pure water.

Each quantity also has anatural unit of measure that can be expressed in terms of the fundamental constants **c, G**, and **h:**

- The **Planck duration** is $(\mathbf{hG/c^5}2\pi)^{1/2}$ or 5.39×10^{-44} sec.
- The **Planck distance** is $(\mathbf{hG/c^3}2\pi)^{1/2}$ or 1.616×10^{-35} m.
- The **Planck mass** is $(\mathbf{hc/G}2\pi)^{1/2}$ or 2.1767×10^{-8} kg.

Derived Concepts

Matter is that which has mass and occupies space. A **body** is any individual coherent material thing.

Deformation is a change in the distances among the points of mass comprising a body. **Rigidity** is the tendency of a body not to deform. **Elasticity** is the tendency of a body to recover from deformation.

The states of matter are:

- A **solid** is a body that does not deform under force and thus has a definite volume and shape.
- A **fluid** is a body that deforms under force.
  - A **liquid** is a relatively incompressible fluid that does not expand indefinitely and thus has a free surface.
  - A **gas** is a compressible fluid that will expand indefinitely.
- A **plasma** is an ionized gas with roughly equal numbers of positive and negative ions, making it electrically conductive and sensitive to magnetic fields. Fluorescent light bulbs create plasmas when turned on.
- An **Einstein-Bose Condensate** is the state of matter cooled so close to absolute zero that its atoms have almost no momentum, which due to the quantum Uncertainty Principle means that their positions are increasingly indeterminate and overlap each other. **Superfluidity** is when super-cooled helium flows without friction or dissipation, and is believed to be due to Einstein-Bose Condensation.

3.1.1.1. Natural Science / Physics / Mechanics / Rigid Mechanics

Rigid Mechanics: the study of the motion of rigid bodies.

Derived Concepts of Translational Motion

Translational motion is motion from point to point in space. The following concepts of translational motion can be derived from the fundamental concepts of mechanics:

- **Force** (**F**) is the scalar ability to change momentum.
- **Position** (**x,y,z**) is the vector in space from the cartesian origin.
- **Displacement** (**s**) is the vector difference in space between two positions.
- **Velocity** (**v** = **s**/**t**) is the vector time-rate of displacement.
- **Acceleration** (**a** = **v**/**t**) is the vector time-rate of velocity.
- **Momentum** (**p** = **mv**) is the vector measure of the motion of a mass.
- **Work** (**W** = **Fs** cos **ß,** where **ß** is the angle between **F** and **s**) is force applied through a displacement.
- **Energy** (**E** = **W**) is the ability to do work. **E** = **Fs** = **mas** = 1/2 **mv**^{2} [because Calculus shows that 2**as** = **v**^{2}]
- **Power** (**P**) is the time-rate of work. **P** = **E**/**t**
- **Action** (**A** = **Et**) is energy **E** applied through some duration **t** and thus measures the magnitude of an event.

Momentum is proportional to velocity, while energy is proportional to acceleration and thus to the *square* of velocity.

Derived Concepts of Angular Motion

Angular motion is motion about an axis. The derived concepts of translational motion all have analogs for angular motion, which is considered in polar coordinates with a fixed radius **r**.

- **Moment Of Inertia** (**I**; analogous to mass) is a measure of resistance to change in angular velocity. $\mathbf{I} = \mathbf{mr}^2$
- **Torque** (**L**; analogous to force), or moment of force, is the ability of an oblique force to change angular momentum. $\mathbf{L} = \mathbf{I}\alpha = \mathbf{Fr} \sin \mathbf{ß}$ [**ß**: angle between **F** and **r**] Note that both Work and Torque are the product of force and distance, but Torque deals with the component of force perpendicular -- rather than parallel -- to the distance.
- **Angular Position** is the angle from the polar origin.
- **Angular Displacement** (ϕ) is the vector difference between two angular positions.
- **Angular Velocity** (ω) is the time-rate of angular displacement. $\omega = \phi/\mathbf{t}$
- **Angular Acceleration** (α) is the time-rate of angular velocity. $\alpha = \omega/\mathbf{t}$
- **Angular Momentum** (**A**) is a vector measure of the angular motion of a mass about an axis. $\mathbf{A} = \mathbf{I}\omega$

Work (**W**) in angular motion is Torque applied through an angular displacement, $\mathbf{W} = \mathbf{L}\phi$**,** and is again equivalent to energy.

Centripetal Force is any force on a body toward the axis of its angular motion. **Centrifugal Force** is the inertia-induced apparent force on a body away from the axis of its angular motion. A bucket spun around an axis by a rope connecting it to that axis experiences centripetal force from the rope. Water in the bucket is held in place by an opposing centrifugal force which is actually just the inertia of the water trying to keep the water going in a straight (tangent) line.

Principles

The **principle of least action**: motion between two points takes the path of minimum action. From this principle can be derived Newton's laws of motion.

Newton's Laws of motion.

1. A body changes velocity only if a force acts on it.
2. Force accelerates a body in proportion to the ratio of the force to the body's mass: $\mathbf{F} = \mathbf{ma}$.
3. To every force there is an equal and opposite reaction force. This implies that momentum is conserved in isolated systems.

Newton's Law of Gravity: the gravitational force between two masses is proportional to the product of their masses and to the inverse square of the distance between them.

Machines. Because $\mathbf{W} = \mathbf{Fs}$ (work = force × displacement) and work (energy) is conserved, the same work can be done by decreasing the force and increasing the displacement. A **machine** so magnifies the effect of a decreased force by applying it through an increased distance, resulting in a **mechanical advantage**. The simple machines:

- The **lever and fulcrum** multiplies force according to the ratio of the lengths of the lever arms. The **wheel and axle** and the **crank** are simply radial levers, with the axle serving as the fulcrum.
- The **inclined plane** multiplies force according to the ratio of length of the plane and the height traversed. The **screw** is simply a radially inclined plan. The **wedge** is a pair of inclined planes.
- The **pulley** multiplies force by the number of free (i.e. length-changing) cords running to the moveable (i.e. force-multiplying) pulley(s).
- The **hydraulic press** multiplies force according to the ratio of the areas of the input and output surfaces, as dictated by Pascal's Law.

3.1.1.2. Natural Science / Physics / Mechanics / Non-Rigid Mechanics

Non-Rigid Mechanics: the study of the motion of non-rigid (elastic and fluid) bodies.

Concepts

The basic concepts of non-rigid mechanics:

- **Stress** is the internal force exerted by one part of an elastic body upon the adjoining part. There are four kinds of stress:
  - **Tension** is stress produced by a pull.
  - **Compression** is stress produced by a push.
  - **Shear** is stress produced by a force acting tangent to a surface.
  - **Torsion** is stress produced by a force acting to twist the body about an axis.
- **Strain** is the deformation caused by stress. **Elastic Limit**is the maximum stress a material can sustain such that the strain disappears when the stress is removed.
- **Density** (**d** = **m**/**V**) is mass **m** per unit volume **V**.
- **Pressure** (**p** = **F**/**A**) is perpendicular force **F** per unit area **A**.
- **Buoyancy** is a reverse (upward) force that an accelerated (weighted) fluid exerts on a body immersed in that fluid.
- **Elastic wave motion** is propagation of deformations through a deformable medium.
- **Harmonic motion** is regular oscillation in which the acceleration of the oscillating object is directly proportional to the displacement of the object from its equilibrium position but oppositely directed.
- **Cohesion** is the attractive force between adjacent parts of a solid or liquid that holds it together and that is caused by electrical forces between molecules.
- **Adhesion** is the attractive force between adjacent parts of two different solids or liquids.

Principles

The basic principles of non-rigid mechanics:

- **Hooke's Law**. Within the elastic limit, the strain produced in an elastic body by a stress is proportional to it. This implies that all elastic matter is capable of harmonic vibration.
- **Depth Pressure**. For a fluid of uniform density **d** under (e.g. gravitational) acceleration (**g**), pressure **p** adds to surface pressure $\mathbf{p_0}$ in proportion to depth **h**: $\mathbf{p} = \mathbf{hdg} + \mathbf{p_0}$
- **Pascal's Law** states that increases in pressure are transmitted equally throughout a fluid. Since **p** = **F**/**A**, a small force **F** applied to a small area **A** can create a larger force but on a larger area. Because the fluid volume is fixed (and because work/energy is conserved), the larger force is applied through a shorter distance than the smaller force. The hydraulic press uses Pascal's Law to multiply force.
- **Archimedes' Principle**. The buoyant force **F** on an immersed body is equal in magnitude but opposite in direction to the force of gravity **g** acting on the mass **m** of the upwardly displaced fluid: **F** = **-gm** = **-gdV**. This can be understood by considering a cylinder of the fluid extending from the fluid's surface down to some depth. Equilibrium demands that the weight of the cylinder of fluid is balanced by an upward force exerted by fluid pressure on the bottom of the cylinder. This upward force causes buoyancy.
- **Boyle's Gas Law**. For a fixed amount of gas at a fixed temperature, pressure is inversely

proportional to volume.

- **Fourier's Theorem**. When two waves travel through a point, the displacement at that point is the vector sum of the displacements produced by the two waves. Any complex harmonic wave can be considered the sum of some number of simple harmonic waves.
- **Refraction, reflection**. The speed of a wave increases with elasticity and decreases with density. When a wave meets a boundary between media of different elasticity or density, part of the wave is reflected back into the original medium, and part is transmitted with a different velocity, thus changing the wave's direction of travel if it were not perpendicular to the boundary.
- **Law of Refraction**. The ratio of the sine of the angle of incidence to the sine of the angle of refraction is equal to the ratio of the wave speeds before and after the boundary.
- **Doppler's Principle**. Relative motion between a wave source and an observer causes a change in the frequency perceived by the observer.

3.1.1.3. Natural Science/ Physics / Mechanics / Relativity

Relativity: the study of gravity and frames of reference.

Special Relativity is the physics of inertial frames. An **inertial frame** is a frame of reference under uniform motion. Special Relativity postulates:

- The speed of light is a finite constant for any observer in an inertial reference frame, regardless of the relative motion of the light source.
- The laws of physics apply the same way in all inertial frames.

The implications of Special Relativity include the following.

- Matter and information cannot propagate faster than the speed of light.
- In a reference frame in motion with respect to the observer, length in that frame contracts in the direction of motion, and time in that frame slows as the motion increases. (So as a train goes by, its cars seem somewhat shorter than when at rest, and its clock runs slower.)
- Events that appear simultaneous to an observer in one reference frame may not appear simultaneous to an observer in another, because the light from the events may reach the observers in different orders. Neither duration nor distance between two separate events can be measured absolutely (i.e. agreed on by observers in all inertial frames), but all observers can agree on the combined spatiotemporal interval between the two events.
- Space and time are aspects of four-dimensional space-time.
- Mass and energy are equivalent and interchangeable, as $\mathbf{E} = \mathbf{mc}^2$.
- Everything moves at the speed of light through space-time. The faster an object moves through space, the slower it moves through time, as measured by a clock that is stationary in the spatial reference frame through which the object moves.

General Relativity is the physics of frames of reference under acceleration. It has two postulates:

- **Relativity** is the principle that local physics is governed by the special theory of relativity.
- **Equivalence** is the principle that gravity and acceleration are locally indistinguishable.

The implications of General Relativity are:

- Gravitational and inertial mass are equivalent.
- Mass-energy curves space-time and thus bends the path of light rays. Spacetime is the seemingly boundless and continuous four-dimensional extent, consisting of three space-like dimensions and

one time-like dimension, in which all matter is located and all events occur, and whose curvature is caused by mass-energy and in turn causes gravity.

- Time passes more slowly in stronger gravitational fields, and light leaving those fields is increased in wavelength.
- The universe is expanding.
- Gravity propagates at the speed of light, and not instantaneously as assumed in Newtonian mechanics. Gravitational waves are disturbances in space-time that result whenever a mass changes velocity. Gravitational waves are what account for the energy and angular momentum observed to be lost from some binary pulsars as they orbit each other.
- The perihelion of an orbit like Mercury's should advance even more than is predicted by Newtonian mechanics as a result of influence from the other planets.

Mysteries

Mach's Principle is that the there is no absolute space and that the structure of space-time depends only on the distribution of matter. Is Mach's Principle true?

3.1.2. Natural Science / Physics / Wave Physics

Wave Physics: the study of the motion of disturbances.

3.1.3. Natural Science / Physics / Thermodynamics

Thermodynamics: the study of heat and its relationship to energy.

Heat

Heat is the total kinetic energy of the random molecular motion of a body. **Temperature** (**T**) is the average kinetic energy of the random molecular motion of a body. **Specific heat** of a substance is the amount of heat per unit mass required to raise its temperature a fixed amount. **Thermal Equilibrium** is the relation shared by two bodies in contact when heat no longer flows between them.

Latent heat is the heat a substance must lose, without changing temperature, in order to change phase from gas to liquid or liquid to solid. **Vaporization** is the change from liquid to gas due to addition of heat but without necessarily changing temperature. **Freezing** is the change from liquid to solid due to removal of heat but without necessarily changing temperature. **Evaporation** is the change from liquid to gas due to the escape of the liquid's more energetic molecules through its surface shared with an unsaturated gas.

Heat Transfer. There are three mechanisms of heat transfer:

- **Thermodynamic Conduction** is heat transfer due to contact.
- **Convection** is heat transfer due to movement of a heated substance.
- **Thermodynamic Radiation** is heat transfer due to electromagnetic radiation.

Stefan's Law: the power (**P**) radiated by a body is proportional to its area (**A**) and to the fourth power of its temperature (**T**): $\mathbf{P} = \mathbf{AT}^4$.

Ideal Gases

An **ideal gas** is assumed to consist of identical point masses undergoing perfectly elastic collisions with each other and with their container. **Ideal Gas Law**: the pressure and volume of an ideal gas are proportional to temperature and inversely proportional to each other: **PV = RT**. The pressure of an ideal gas is proportional to both the number of molecules per unit volume and the average kinetic

energy per molecule.

Laws of Thermodynamics

The laws of thermodynamics are statistical laws that only apply to systems with many particles. The improbability of violations of these laws rises exponentially with the number of particles in the system. For all but the most microscopic systems, these laws are effectively inviolate.

- **0th Law of Thermodynamics**: if two bodies each are in thermal equilibrium with a third body, then they are in thermal equilibrium with each other.
- **1st Law of Thermodynamics**: energy cannot be created or destroyed and thus is conserved. The change in internal energy (d**U**) of a system is the difference between the heat (**Q**) transferred into (or out of) the system and the work (**W**) done by the system: d**U** = **Q** - **W**.
- **2nd Law of Thermodynamics**: heat does not spontaneously flow from a cold body to a hot body, and so the entropy of a closed system can never decrease.
- **3rd Law of Thermodynamics**: a finite process can lower a body's temperature arbitrarily close, but not all the way, to absolute zero.

Entropy

Entropy is a measure of the disorder in a system, and the change in entropy (d**S**) is defined as the change in heat divided by the absolute temperature: d**S** = d**Q** / **T**. Isolated systems tend to increase in entropy, and thus the entropy of the universe increases in all natural processes.

3.1.4. Natural Science / Physics / Electromagnetics

Electromagnetics: the study of the behavior of electromagnetic charge.

Light is electromagnetic radiation: the propagation of variations in the electromagnetic field. Light defines the speed at which everything moves through space-time.

Atoms such as iron are permanent magnetic dipoles. A **magnet** is a macroscopic magnetic dipole composed of multitudes of magnetic dipoles (such as iron atoms) that are locked in alignment.

3.1.5. Natural Science / Physics / Quantum Physics

Quantum Physics: the study of the smallest amounts of matter and radiation.

Motivating Phenomena

The atomic theory of matter was inferred from the integral ratios of elements comprising chemical compounds, the successes of the kinetic theory of gases, and the Brownian motion of particles suspended in water. The nuclear theory of atoms was inferred from the existence of electrons, radioactivity, and especially the scattering of alpha particles directed at thin foils. Quantum theory was inferred from

- the stability of the electron orbits in atoms, and their associated spectral lines;
- the finite amount of ultraviolet radiation from heated bodies;
- the dependency of photoelectricity on light frequency and not intensity; and
- Compton scattering of X-rays from electrons.

Several different phenomena exemplify the differences between classical and quantum physics.

- *Double-slit interference*. Quanta (e.g. photons or electrons) are emitted one by one toward a screen protected by a barrier with two slits. When it is checked which slit each quantum passes

through, they impact the screen directly behind the transited slit. When it is not checked, they impact the screen in an interference pattern suggesting that each quantum travels as a wave through *both* slits and interferes with itself.

- *Non-locality*. Twin particles are emitted in opposite directions so that they have opposite spin. The spin, like the path through the double-slit, is indeterminate until measured. A measurement of one particle's spin instantaneously determines the other's, even if they are light-years apart.
- *Delayed choice*. In a modified double-slit experiment, one may choose to replace the screen, a moment before each quantum hits it, with a detector that can determine which slit the quantum transited. The choice can happen well after the quantum has transited the slitted barrier, and yet this delayed choice again determines whether the quantum self-interferes on the screen or is counted by one of the two detectors.

Principles

Quantization. A **quantum** is a discrete unit of some physical property or phenomenon. A property or phenomenon is quantized if it can only occur in discrete units. In addition to the quantized fundamental properties, quantized phenomena include:

- matter, the fundamental quanta of which are quarks and leptons;
- action, which is quantized as a function of Planck's constant **h**;
- vibration, the quanta of which are called phonons;
- electric conduction;
- thermal conduction

Wave-particle duality. Every quantum has both wave-like and particle-like properties. As demonstrated in double-slit interference, quanta travel like waves but arrive like particles.

Complementarity. Quanta have complementary properties that cannot be observed or measured simultaneously. Complementary properties include:

- position and linear momentum;
- energy and time; and
- angular momentum along the three spatial axes.

Indeterminacy. Different quanta in the same state can nevertheless behave differently, for example by undergoing radioactive decay at different times. This is not due simply to observers lacking information about determinate underlying variables that could, if known, be used to predict the behavioral differences. Instead, as Heisenberg proposed in 1927, the indeterminacy is built in at the lowest level. The **Heisenberg Uncertainty Principle** states that complementary properties cannot be measured simultaneously and in fact have no precise definite value, measurable or not.

Fields

A **field** is a region in which a force or effect exists. Changes in fields propagate at the speed of light. All the fields observed in nature are continuous over space and time, are (or are thought to be) quantized in their particle interactions, and exhibit gauge symmetry. **Gauge symmetry** is an invariance at each point in space and time. There are fields associated with each of the fundamental forces.

The weak force is chiral: it includes phenomena whose mirror-reflected counterparts seem never to occur. This is strong evidence that there must be an odd number of space-like dimensions, since chirality cannot exist in an even number of space-like dimensions. (Reflection along an even number of axes is equivalent to rotation, and invariance under rotation is a fundamental symmetry in nature.)

Field theories.

- **Quantum Mechanics** is the quantum theory of atomic structure and associated radiation that was developed in the 1920s.
- **Quantum Electrodynamics** is the quantum theory of electromagnetism that was developed in the 1940s.
- **Electroweak Theory** is the unified quantum theory of the electromagnetic and weak forces that was developed in the 1960s.
- **Quantum Chromodynamics** is the quantum theory of the strong force that was developed in the late 1960s.
- The **Standard Model** is the unification of electroweak theory and quantum chromodynamics that was developed in the early 1970s and that explains all observed particle interactions except those due to gravity.
- **String Theory** or **M Theory** is a proposed quantum theory of all particles and fields, based on one-dimensional "strings" resonating in a ten-dimensional space-time whose six extra space-like dimensions are "curled up" at each point, just as a hose is a one-dimensional line with a small two-dimensional circular cross-section at each point.

Particles

A **particle** is a quantum of matter or energy that has observable position. The most basic way to classify particles is according to their angular momentum.

- **Fermions** are all subatomic particles that have the half-integral angular momentum that subjects them to the Pauli exclusion principle, and include quarks, leptons, baryons, and nuclei of odd mass number.
- **Bosons** are all subatomic particles that have the integral angular momentum that exempts them from the Pauli exclusion principle, and include gauge bosons, mesons, and nuclei of even mass number.

Another classification of particles is according to how they are composed of constituent particles.**Hadrons** are baryons and mesons: the subatomic particles composed of quarks and thus subject to the strong nuclear force.

- **Mesons** are short-lived spin-zero bosons that are composed of a quark and antiquark and that quickly decay into other particles.
- **Baryons** are fermions, such as the proton and neutron, that are composed of three quarks, and that have baryon number of ±1.
    - **Nucleons** are either of the two kinds of baryons (protons and neutrons) that constitute atomic nuclei and thus account for over 99.9% of the mass of atomic matter.
        - **Protons** are positively-charged nucleons that are composed of two up quarks and one down quark, that are the essential constituents of the atomic nuclei of ordinary matter, and that have an average life of at least 10^{32} years.
        - **Neutrons** are uncharged nucleons that are composed of one up quark and two down quarks, that account for differing isotopes by their varying numbers inside atomic nuclei, and that are the seed of nuclear radioactivity due to the instability that makes their average free life last only about 900 seconds.

Atoms are particles that consist of electrons orbiting a nucleus composed of nucleons, that are the smallest units into which matter can be divided without releasing electrical charge, and that are the characteristic units of chemical elements. A **nucleus** is the tiny dense positively-charged central core of

an atom, consisting of neutrons and mutually-repelling protons that are held together by the strong force and that attract electrons into orbiting quantum shells that give the atom its chemical properties.

Interpretation

A quantum system remains in an indeterminate but deterministically-evolving state until the next measurement or observation event. Such an event happens when the function has interacted with other wave functions to an effectively irreversible degree. Observation of an event is thus the irreversible widening of the scope of influence of the event. Observation "collapses" the wave function discontinuously and non-deterministically into a particular determinate state.

Bohr's **Copenhagen interpretation** of quantum theory is that reality should not be assumed to have properties that exist independently of their being measured. Einstein's **hidden variables** hypothesis is that future physical theories will reveal that the fundamental properties of reality have values that are independent of their being measured. Everett's **many worlds** hypothesis is that at each measurement or observation event the universe branches into a separate universe for each possible outcome of the event. `The hidden variables hypothesis is not supported by available evidence. The many worlds hypothesis is unfalsifiable, unverifiable, and therefor meaningless.`

Quantum indeterminacy is on such a small scale that it is unlikely to affect macroscopic processes such as volition in the brain. However, quantum indeterminacy does in principle make strong free will possible. At the same time, too much indeterminacy would threaten to undermine the ethically more important property of weak free will.

If quantum indeterminacy did not exist (i.e. if Planck's constant were zero), then it seems that an arbitrarily small volume of space-time could contain an arbitrarily large amount of information. The positions of the particles in any volume could in principle be measured to arbitrary precision, extracting arbitrary amounts of information. Similarly, the positions of the particles could in principle be adjusted to arbitrary precision, thus storing arbitrary amounts of information. Completely faithful and precise simulations of actual physical subsystems would be impossible, because infinite amounts of information would be required to accurately specify the positions of particles. Quantum indeterminacy thus seems consistent with the logical possibility that the universe is in fact a simulation running on some computational substrate (whose random number generator would constitute the ultimate hidden variable). Of course, since this possibility is probably unverifiable, parsimony requires that it be rejected pending other evidence.

Mysteries

What determines the particular mass values of quarks and leptons? Do protons ever decay, implying that quarks and leptons can be interconverted by means of some new gauge boson? Why are there precisely three generations of fundamental particles?

3.2. Natural Science / Astronomy

Astronomy: the study of extraplanetary space and its contents.

1. **Cosmology**.
2. **Galactic Astronomy**.
3. **Stellar Astronomy**.

4. **Planetary Astronomy**.

3.2.1. Natural Science/ Astronomy / Cosmology

The physical universe is everything that is, has been, or ever might be in causal contact with Earth. The **observable universe** is that part of the universe that is or has been in causal contact with Earth. Human knowledge of the universe outside the observable universe is limited by the rate at which Earth's sphere of causal contact is growing (namely, the speed of light).

Origin of the Universe

Spacetime; what was before the Big Bang? What caused the Big Bang?

Big Bang. evidence: 2.73K blackbody radiation, Hubble's Law (good to 1 part per million)

Inflation explains why the universe is isotropic, by allowing opposite ends of the observable universe to have once been in causal contact, even though today they are 20 Gly apart. Inflation also explains why the observable universe appears flat.

History of the Universe

Graph universe's size, temperature, density on log-log scale

Nature of the Universe

The universe is believed to have no boundary in the three familiar dimensions, in the same sense that a sphere has no boundary in the two dimensions of its surface. Thus the universe has no end or edge, and so nothing is outside the universe or "beyond its edge". For the size of the universe, humans only know a lower bound -- namely, the size of the observable universe -- and probably cannot know an upper bound, although it is often assumed to be finite.

The observable universe is about 12-14 billion light-years in radius. At the limits of our observation are the Big Bang singularity (for the time-like dimension) and just-now-visible parts of the universe (for the space-like dimensions).

cosmic background anisotropy.

universe map (cf. Galaxies by Ferris p. 160)

shape unknown: open, closed, or flat

Fate of the Universe

Misunderstandings

Anthropic principle. Before big bang. Outside universe.

Mysteries

What is the fate of the universe: open, closed, or asymptotically flat? What is the dark and presumably non-baryonic matter that seems to be needed to account for the gravitational mass of galaxies? What happened in the first 10^{-43}s? Why does there seem to be more matter than antimatter? What causes gamma ray bursters? Why are there fewer solar neutrinos than predicted?

3.2.2. Natural Science / Astronomy / Galactic Astronomy

3.2.3. Natural Science / Astronomy / Stellar Astronomy

3.2.4. Natural Science / Astronomy / Planetary Astronomy

Where Earth is going

- Earth rotates on its axis once every 23.93 days (23h 56m 4.09s), for a speed of 0.5 km/sec at the equator. Earth's axis precesses every 25,800 years around a circle with a diameter of 47 degrees.
- Earth revolves around the Sun once every 365.24 days (365d 5h 48m 45.51s), at an average speed of 30 km/sec.
- The Sun is drifting amongst nearby stars towards 18.1h+30° at 20 km/sec.
- Sun and nearby stars revolve around the center of Milky Way once every 226 million years, at an average speed of 200 km/sec.
- The Milky Way and the Andromeda Galaxy are moving towards each other at 50 km/sec within the Local Group.
- The Local Group is pulled within the expanding Virgo Supercluster toward the central Virgo Cluster at 170 km/sec, reducing to 930 km/sec the speed at which the Virgo Cluster recedes due to the expansion of the universe.
- The Virgo Supercluster is falling at 600 km/sec (relative to the 3K cosmic background), toward the Great Attractor 150 Mly away at 10h-20°.

Where Earth is

- [Sky map
  - cosmic background anisotropy
  - Virgo cluster, supergalactic plane
  - naked-eye galaxies: Andromeda, Magellanic Clouds
  - Milky Way: disk, plane, nucleus, arms?
  - constellations
  - brightest stars, nearest stars
  - solar ecliptic plane
  - voyagers, pioneers
- universe map (cf. Galaxies by Ferris p. 160)
- Virgo supercluster (cf. Galaxies by Ferris p. 145)
- Local Group (cf. Galaxies by Ferris p. 74)
- Milky Way map (cf. Galaxies by Ferris p. 34)
  - Orion and Sagittarius arms
- Milky Way "photograph": M74? NGC5364? NGC5371? NGC5985? NGC3938?
- solar neighborhood map
  - nearby stars
- planets, moons, asteroids, comets
- planetary surfaces: venus, mars, moon

- relative sizes: moons, planets, sun, dwarfs, betelgeuse]

Earth's Sky

Brightest Objects.
[Adapted from Norton's 2000.0 (c) 1989 and from Hipparcos ranging]

Object	Apparent Magnitude	Distance (ly)	Apparent Size	Ascen.	Declin.	Notes
Sun	-26.72	8 light-min	1800"			
Moon	-12.6	1 light-sec	1800"			Impacted 1000 CE?
Venus	-4.5		59"-9"			
Jupiter	-2.9		49"-32"			comet impact: 1994
Mars	-2.7		25"-3"			
Mercury	-2.2		12"-4"			
Sirius	-1.46	8.6		06 45	-16 43	SW of Orion; + w dwarf
Canopus	-0.72	313		06 23	-52 42	
α **Centauri**	-0.27	4.4		14 42	-60 59	
Arcturus	-0.04	37		14 15	19 11	pointed to by Big Dipper's handle
Saturn	+0.0		19"-15"			
Vega	+0.03	25		18 36	38 47	dust disk
Capella	+0.08	42		05 16	46 00	between Orion & Polaris
Rigel	+0.12	800		05 14	-08 12	Orion's SW foot
Procyon	+0.38	11.4		07 39	05 13	+ w dwarf; 2 hr L of Betelgeuse
Achernar	+0.46	145		01 37	-57 14	
Betelgeuse	+0.50	430	0.04"	05 55	07 24	Orion's NE shoulder; 1st sized star: 1920
β **Centauri**	+0.61	525		14 04	-60 22	
Acrux	+0.76	320		12 27	-63 06	visual binary
Altair	+0.77	16.8		19 51	08 52	
Aldebaran	+0.85	65		04 36	16 30	between Orion & Pleiades; path of Pioneer 10

Nearest Stars.
[Compiled by C. Anderson, S. Clegg, and T. Studebaker from Hipparcos satellite data and the Yale Catalog of Trigonometric Parallaxes.]

Object	Apparent Magnitude	Distance (ly)	Ascen.	Declin.	Notes
Sun	-26.72	0.000006			
Proxima Centauri	11.05	4.22	14 32	-62 49	faint companion to..
α **Centauri A**	-0.01	4.39	14 42	-60 59	..α Centauri

α **Centauri B**	+1.33	4.39	14 42	-60 59	
Barnard's Star	+9.54	5.94	17 58	+04 36	fastest star: 10 "/yr
[2 dwarfs]	[+7 - +13]	[7 - 8]			
Sirius A,B	-1.46	8.60	06 46	-16 45	B: white dwarf
[4 dwarfs]	[+10 - +12]	[8.7 - 10.3]			
e Eridani +	+3.73	10.49	03 33	-09 28	1st ranged star: 1838; has Jovian planet w/ 7yr orbit
[3 dwarfs]	[+7 - +13]	[10.7 - 11.2]			
61 Cygni A,B	+5.2	11.35	21 07	38 45	B: white dwarf
Procyon A,B	+0.38	11.4	07 39	05 13	B: white dwarf

Distant Visible Objects.

Object	Apparent Magnitude	Distance (ly)	Size (ly)	Apparent Size	Ascen.	Declin.	Notes
Andromeda Galaxy: M31	3.4	2.9M	200K	180'	0 43	+41 16	1st ranged galaxy: 1920; hosted 1885 supernova
Small Magellanic Cloud	2.3	210K		180'	0 53	-73	
Large Magellanic Cloud	0.1	179K	50K	600'	5 24	-70	1987 supernova was nearest since 1604
Milky Way		30K	100K	360º			supernovae in 1604, 1572, 1054, 1006
Hercules Globular Cluster: M13	5.8	23K	150	16'	16 42	+36 28	100K stars; target of Arecibo message
Ω Centauri: NGC5139	3.7	16K			13 27	-47 29	biggest Milky Way cluster: 5M solar masses
NGC104	4.0	13K	120	31'	00 24	-72 05	47 Tucanae; adjacent to Small Magellanic Cloud
M22	5.1	10K	65	24'	18 36	-23 54	globular cluster

Orion Nebula: M42 & M43	4.0	1.5K	30	60'	05 35	-05 27	middle "star" of Orion's sword
Betelgeuse	0.5	1.4K	10^{12}m	0.04"			biggest star: larger than Mars' orbit; 20 solar masses
Pleiades: M45	1.6	380		110'	03 47	+24 07	Seven Sisters; Subaru; open cluster of 500 stars

Earth Impacts

"The four largest terrestrial-impact craters known: Chesapeake Bay on the East Coast of the United States and Popagai in Siberia (both dated at 35 million years), Chicxulub on the Yucatán peninsula (65 million years old and suspected of being produced by the impactor that may have killed the dinosaurs) and Manicouagan in Quebec (dated at 210 million years)."

Space Exploration

Voyager. In February 1991, from a vantage point 3.7 billion miles from Earth and about 32 (35?) degrees above the plane of the ecliptic, Voyager 1 returned an historic "family portrait" of nearly all the planets in our solar system. Voyager 1 is now farther from Earth than any other spacecraft, and is travelling at 63 Mm/h in the opposite direction as Pioneer 10. Voyager 1 is escaping the solar system at a speed of about 3.5 AU per year, 35 degrees out of the ecliptic plane to the north, in the general direction of the Solar Apex (the direction of the Sun's motion relative to nearby stars). Voyager 1 will leave the solar system aiming toward the constellation Ophiuchus. In the year 40,272 AD, Voyager 1 will come within 1.7 light years of an obscure star in the constellation Ursa Minor (the Little Bear or Little Dipper) called AC+79 3888.

Voyager 2 is departing southward at 56 Mm/h, 48 degrees out of the ecliptic plane to the south toward the constellations of Sagitarrius and Pavo. In about 40,000 years, Voyager 2 will come within about 1.7 light years of a star called Ross 248, a small star in the constellation of Andromeda

Pioneer. Pioneer 11is headed toward the constellation of Aquila (The Eagle), Northwest of the constellation of Sagittarius. Pioneer 11 may pass near one of the stars in the constellation in about 4 million years.

3.3. Natural Science / Chemistry

Chemistry: the study of substances and their properties.

3.4. Natural Science / Geoscience

Geoscience: the study of the physical composition and behavior of planets.

1. **Geology**.
2. **Geography**.

3. **Oceanography**.
4. **Meteorology**.

3.4.1. Natural Science / Geoscience / Geology

Radioactive decay keeps the earth's core molten, generating a magnetic field that protects the biosphere from ultraviolet(?) radiation. The magnetic field reverses polarity every ? million years. What causes the reversal? How does the reversal affect the biosphere?

Plate tectonics

- Continental Plates
  - Eurasian
  - Indo-Australian - rammed north into Eurasia, creating Himalayas
  - North American - sliding south against Pacific on San Andreas fault
  - South American - separated from Africa, widening Atlantic
  - African - beginning to split in E. Africa along a N-S rift
  - Antarctic
- Oceanic Plates
  - Pacific
  - Nazca - sliding underneath S. America, creating Andes
  - Cocos - sliding underneath Mexico and Caribbean plate
- Minor Plates
  - Caribbean - sliding E over Atlantic floor, creating Antilles
  - Juan de Fuca - sliding underneath Washington St., created Cascades
  - Scotia
  - Arabian - drifting NE, widening Red Sea
  - Turkish-Aegean
  - Philippine

3.4.2. Natural Science / Geoscience / Geography

- N. America
  - Greenland
- S. America
- Africa
- Eurasia
  - Europe
  - Asia
- Oceania
  - Australia
  - New Guinea

    - Melanesia
    - Micronesia
    - Polynesia
- Antarctica

3.4.3. Natural Science/ Geoscience / Oceanography

- Atlantic
    - North Sea
    - Baltic Sea
    - Mediterranean Ocean
    - Black Sea
    - Gulf of Mexico
    - Caribbean Sea
- Pacific
    - Bering Sea
    - Sea of Okhotsk
    - Sea of Japan
    - East China Sea
    - Yellow Sea
    - South China Sea
    - Java Sea
    - Coral Sea
    - Tasman Sea
- Indian
    - Red Sea
    - Persian Gulf
- Arctic

3.5. Natural Science / Biology

Biology: the study of life.

1. **Molecular Biology**: the study of biologically active substances and their properties.
2. **Cellular Biology**: the study of cells.
3. **Physiology**: the study of the functional subsystems of organisms.
4. **Ethology**: the study of the behavior of organisms.
5. **Evolutionary Biology**: the study of the generational development of organisms.
6. **Anthropology**: the study of humans as animals.
7. **Ecology**: the study of how organisms relate to their environment.

8. **Exobiology**: the study of life beyond the Earth.

Life is functional organization for sustaining self and kind involving active use of energy and information replication, respectively. **Living** is functioning organization for sustaining self as part of a system that constitutes life. **Death** is the irreversible cessation of living. A wide variety of systems undergo replication or are self-sustaining, but not all of those systems are alive.

- **Replicas** are entities whose kind is sustained by copying.
    - **Replicators** are entities which sustain their kind by copying themselves.
        - Living replicators make active use of energy to sustain themselves.
            - **Organisms** are any entity which is or once was living and that is of the kind sustained by its functional organization.
                - *Spores* and *fertilized seeds* are organisms because they can germinate even if dormant for up to thousands of years.
                - *Immature organisms* such as zygotes, embryos, fetuses, and children are all nevertheless organisms.
                - *Mutualist* and *parasitic symbionts* are distinct organisms only to the extent that they are of a kind being sustained distinctly. If the sustaining of their kinds is inextricably linked (as with mitochondria and their host cells), then they are part of the same organism.
                - *Artifacts* (such as *robots*) can be organisms if they sustain self and kind. If they are obligate mutualists with another artifact (e.g. a factory for building robot-factory-building-and-sustaining robots), then they are each in effect a separate sex of a common species.
                - *Sterile organisms* such as mules and worker bees are alive because they sustain themselves and are part of a functional organization for sustaining kind.
                - *Dormant organisms* such as hibernators remain alive insofar as they have the possibility and likelihood of continued living. Fallible knowledge of such possibilities and likelihoods can make it non-obvious whether an organism should be considered dead.
                - *Immortal organisms* that no longer replicate are nevertheless organisms if they have parents (and not just producers).
            - *Sub-organismic replicators* like *cells*, *mitochondria*, *chloroplasts*, and *gametes* are not organisms because, while they sustain and replicate themselves, they are not of the kind that they are organized to sustain.
            - **Artificial life** is life that exists in a simulation and uses simulated energy instead of real energy. If the universe is a simulation, then all known terran life is in fact artificial life, but life nonetheless.
        - **Self-catalyzing replicators** make no active use of energy but are structured to cause copying of themselves. They are not alive because they do not use energy or other resources to sustain themselves and in fact usually have unchanging internal state.
            - *Viruses*, *viroids*, and *prions*
            - *Genotypes*, *chromosomes*, and *genes*

        - *Software viruses* and *worms*
        - *Chain letters, religious beliefs*
    - **Replicants** are entities which are copied but do not copy themselves.
        - **Memes** are patterns of information which tend to get replicated from one mind to another. Ideas, words, languages, jokes, stories, texts, images, etc. are all memes or meme complexes.
        - *Artifacts* such as cars or robots can be described in physiological terms and yet are not alive because they do not reproduce and do not even really sustain themselves.
- **Self-sustaining non-replicas**
    - *Communities* such as families and societies sustain themselves but are not alive because they are not truly replicated.
    - *Sub-organismic components* such as limbs and organs are alive but are not organisms because they do not replicate themselves.
    - *Self-sustaining processes* such as fires, tornados and stars are not alive because they have no functional organization.

3.5.1. Natural Science / Biology / Molecular Biology

Molecular Biology: the study of biologically active substances and their properties.

3.5.2. Natural Science / Biology / Cellular Biology

Cellular Biology: the study of cells.

3.5.3. Natural Science / Biology / Physiology

Physiology: the study of the functional subsystems of organisms.

1. **Reproductive Systems**.
2. **Respiratory Systems**.
3. **Digestive Systems**.
4. **Circulatory Systems**.
5. **Supportive-Protective Systems**.
6. **Actuating Systems**.
7. **Immune Systems**.
8. **Cybernetic Systems**: systems that control and coordinate the operations of organisms.

3.5.3.1. Natural Science / Biology / Physiology / Reproductive Systems

3.5.3.2. Natural Science / Biology / Physiology / Respiratory Systems

3.5.3.3. Natural Science / Biology / Physiology / Digestive Systems

3.5.3.4. Natural Science / Biology / Physiology / Circulatory Systems

3.5.3.5. Natural Science / Biology / Physiology / Supportive-Protective Systems

3.5.3.6. Natural Science / Biology / Physiology / Actuating Systems

3.5.3.7. Natural Science / Biology / Physiology / Immune Systems

3.5.3.8. Natural Science / Biology / Physiology / Cybernetic Systems

Cybernetic Systems: systems that control and coordinate the operations of organisms.

In terran organisms, cybernetic systems consist primarily of endocrine and nervous systems.

Endocrine Systems

Nervous Systems

A **nervous system** is in terran organisms a network of neurons organized to process sensations and produce behaviors. A **neuron** is a cell that processes electrochemical stimuli received from its branch-like dendrites and at some threshold emits a characteristic electrochemical response along its single outgoing axon. Signals travel in the nervous system at speeds of up to 100 m/s.

The **brain** is the part of the vertebrate nervous system responsible for regulating and controlling bodily activities, including autonomic functions, sensation, movement, and cognition. The **brain stem** controls most autonomic functions and is involved in emotional and reproductive behavior. The **cerebellum** controls voluntary muscular activities. The **cerebrum** is responsible for sensation, volition, and cognition.

Inputs to Nervous Systems

Nervous systems are sensitive to a wide variety of stimuli.

- **Mechanoreception** is sensitivity to mechanical stimuli.
  - **Tangoreception** is sensitivity to touch, and is found in almost all kinds of organisms. Vibrations in touched objects can be sensed by many animals.
  - Air and water displacement can be sensed by many invertebrates and aquatic vertebrates. Water pressure can be sensed by many aquatic animals.
  - Most animals use internal mechanoreceptors to sense the movements and positions of their own body parts.
  - **Statoreception** is sensitivity to acceleration (such as caused by gravity), and is found in most animals. Invertebrate (but not insect) statoreception senses the disposition of a mineral particle in specialized vesicles. Vertebrate statoreception senses the disposition of calcium carbonate particles in the inner ear.
- **Thermoreception** is sensitivity to temperature.
- **Chemoreception** is sensitivity to chemicals, and is found in all animals. **Taste** is contact chemoreception of water-soluble substances. **Smell** is distance chemoreception of water-insoluble vaporous substances.
- **Photoreception** is sensitivity to light and its polarization. Humans have photoreceptors that are specially sensitized to red, green, and blue light, and are unable to distinguish between mixtures of these three and pure samples of other colors. Humans can see light between 400 nm and 750 nm, and flickering up to 60 Hz.
- **Sonoreception** is sensitivity to sound. Animal sonoreception can detect sounds as low as 0.1 Hz (pigeon) and as high as 240 KHz (moth). Humans can hear sounds between 20 Hz and 20 KHz.

Echolocation is the emission of sounds and the sensing of their reflections in order to perceive nearby reflecting objects. Echolocation is found in bats and toothed whales.

- **Electroreception** is sensitivity to electrical stimuli, and is found in certain kinds of fish and in the platypus. Some eels are able to generate a local electric field in order to detect changes in it caused by prey. Certain insects and birds appear able to sense magnetic fields.

Functions of Nervous Systems

Autonomic functions.

Movement.

Pain.

Perception.

Appetitive Behavior. Fighting, fleeing, mating, feeding, etc.

Cognitive Behavior. All human cognitive functions seem to consist ultimately in the activation and modulation of synaptic connections in the cerebrum. The human cerebrum is divided into two hemispheres, one of which is dominant in each individual. The dominant hemisphere is responsible for language, mathematics, and handedness. The other hemisphere is responsible for face recognition and emotional, spatial, and musical processing.

The frontal lobes of the cerebrum are responsible for attention, volition, planning, and conscience. The motor cortex of each frontal lobe controls the voluntary muscles of the body's opposite side. The somatosensory cortex of each parietal lobe receives and integrates input from mechanoreceptors and thermoreceptors on the body's opposite side. The visual cortex in each occipital lobe processes input from the opposing half of each eye's visual field, providing e.g. recognition of faces and perception of motion. The auditory cortex in each temporal lobe processes auditory input from both sides of the body, and has areas for the comprehension and production of language. The non-dominant temporal lobe analyzes the emotional content of faces.

Immediate memory seems to be stored in the frontal lobes. Short-term memory is processed by the hippocampus. Episodic long-term memory seems to be stored in the temporal lobes, whereas the parietal lobes seem responsible for general long-term memory. Long-term memories seem not to be stored at particular points in the brain, but rather in diffuse associative networks.

How are memories created, stored, recalled, and forgotten? How does the brain understand and generate language? How does the brain perform learning and reasoning? What happens in the brain as it makes a decision? How does the brain generate and process emotions? How does the brain control attention? What is the neurophysiological purpose, if any, of sleeping and dreaming?

3.5.4. Natural Science / Biology / Ethology

Ethology: the study of the behavior of organisms.

3.5.5. Natural Science / Biology / Evolutionary Biology

Evolutionary Biology: the study of the generational development of organisms.

1. **Genetics**.
2. **Paleontology**: the study of life in the past.
3. **Taxonomy**: the study of the relationships of organisms.

Evolution

Evolution is accumulated change in a lineage of entities through inheritance of new variation. All known terran organisms are related by their evolution from common origins. In particular, humans and all other primates evolved from a common ancestor. The tens of millions of species living on Earth were all created by a process of evolution from common origins that also created hundreds of millions of species now extinct.

Evolution is not simply any change in an entity. Individual organisms develop, not evolve. Evolution does not inevitably cause "progress" toward "higher" forms. Evolution can remove features (such as eyes and limbs) as well as add them. Evolution is not constrained to creating increasing complexity. However, as an ecosystem develops, extremes of complexity can become more likely due to accumulation of complicating changes in some lineages.

Evidence for Evolution

There are several different major kinds of evidence for evolution.

- *Taxonomical* evidence shows that all terran organisms fit into taxonomical categories suggesting phylogenetic relationships.
- *Genetic* evidence reveals details of phylogenetic relationships, extending (and largely confirming) the taxonomical understanding of phylogeny. Genetic evidence also shows that all terran life shares common origins.
- *Paleontological* evidence reveals an increasingly detailed fossil record of the missing links and dead ends in the family tree of terran life.
- *Physiological* and *biochemical* evidence includes myriad homologies of anatomy, embryonic development, and biochemistry that confirm and elaborate how organisms are related. Particularly telling are the anatomical vestiges and evolutionary imperfections that show how blind evolution can be.
- *Biogeographical* evidence shows how isolated populations are subject to evolutionary divergence and convergence.

Convergent evolution occurs when taxa under similar selective pressures come to share a trait that their common ancestors did not share. Convergent evolution is particularly interesting because it suggests the topology of the design space that evolution searches. For important evolutionary pathways like those resulting in sociality and intelligence, convergent evolution hints at how likely they were on Earth and how likely they might be elsewhere.

- Trait convergence occurs when a single trait is shared.
    - Fish and cetaceans have both evolved streamlining, tail propulsion, and fin steering.
    - Pterodactyls, birds, and bats all evolved wings from their tetrapodal forelimbs.
    - Pinnipeds and penguins both evolved propulsive fins from their tetrapodal forelimbs.
    - Cetaceans and bats both evolved echolocation.
    - Mole rats and many insects evolved eusociality.

    - Cephalopods and vertebrates both evolved camera-like eyes.
- Niche convergence occurs when geographically separated taxa become so similarly adapted that they exploit similar niches.
    - The marsupials of Australia are more closely related to each other than to placental mammals, and yet include organisms similar to the wolf, big cat, flying squirrel, anteater, mole, mouse, and hare.
    - Africa, South America, and other isolated locales have evolved multiple separate analogs of the ostrich, hare, anteater, and cactus.

Natural Selection

Natural selection is differential reproductive success due to inherited variation. Natural selection is the most important factor in the evolution of terran life. Sexual selection is a form of natural selection in which competition for mates causes differences in reproductive success and a resulting exaggeration of traits that aid in mate competition.

Natural selection acts on individual organisms, and not on groups or species of organisms.
The **inclusive fitness** of an individual organism is the relative number of its alleles that are passed on to subsequent generations by the organism or its relatives. Natural selection favors variations that increase a genotype's inclusive fitness. Natural selection for maximum inclusive fitness can lead some individuals to forego reproduction in order to help relatives reproduce. It can lead other individuals to compete with parents or siblings, cheat on mates, or commit infanticide against a mate's unrelated offspring.

3.5.5.1. Natural Science/ Biology / Evolutionary Biology / Genetics

3.5.5.2. Natural Science / Biology / Evolutionary Biology / Paleontology

Paleontology: the study of life in the past.

Genesis

How precisely did life on Earth arise? Life on Earth is probably the result of a long series of increasingly complex auto-catalytic cycles of molecular synthesis that were subject to preferential replication through natural selection. Humans will require decades or even centuries to reconstruct through theory and experiment the details of how life arose. How probable or improbable was the beginning of life on Earth? Humans do not yet know, but the case for probability is being strengthened by both a) earlier estimates of how soon life arose after the Earth formed, and b) an increasing understanding of the steps genesis may have taken.

The methane, ammonia, water, and hydrogen sulfide on the early Earth would have been readily combined by lightning, heat, or ultraviolet radiation into organic molecules like amino acids, sugars, and nucleic acids. Clays or other mineral surfaces may have served as catalysts or concentrators for polymerization of these organic molecules. Nucleotide phosphates could have spontaneously assembled into polynucleotides, which then would be templates for further such assembly. Errors in copying could have led to a population of various replicating polynucleotides. Some polynucleotides could have weakly but selectively bonded with particular amino acids to construct various proteins. Any polynucleotide whose associated protein helped catalyze that polynucleotide's assembly would have preferentially reproduced. Mutually catalyzing cycles of protein synthesis could have caused the evolution of enzymes.

Cells may have arisen as proteinoid microspheres forming spontaneously and helping maintain concentrations of proteins or enzymes which themselves made microsphere formation more likely. Cell division and reproduction may have developed from the tendency of some microspheres to rupture (perhaps after some form of growth) into two or more spheres. Natural selection would favor those resulting spheres that retained a complement of nucleic acids, proteins, and enzymes sufficient to continue the sphere's cyclical catalysis, which would at some point be considered the metabolism of a spherical cell.

The earliest bacteria were chemotrophs deriving energy from inorganic chemicals in their environment, but around 3.5 Gya some bacteria evolved into phototrophs that could capture and store the energy from sunlight. The earliest first form of photosynthesis split hydrogen sulfide to produce ATP and waste sulfure.

Biogeological History

Name	Began	Characterized By
Archaeozoic Eon	4.7 Gya	Before life
Proterozoic	3.6 Gya	Simple life
Phanerozoic	590 Mya	Visible life
Paleozoic Era		Arthropods, amphibians
Mesozoic	248 Mya	Reptiles, ferns, conifers
Cenozoic	65 Mya	Mammals, flowers
Tertiary Period		
Quaternary	1.64 Mya	
Pleistocene Epoch		Ice Ages, hominids
Holocene	13 Kya	Warmth, Homo sapiens

Revolutionary Advances

The most important contingent non-parochial revolutionary advances.

Advance	When	Notes
Big Bang?	15 Gya	Earth: 4.7 Gya Oceans: 3.8 Gya?
Life	>3.85 Gya	glycolysis, replication, genes, cells
Photosynthesis	3.5 Gya	
Endosymbiosis	>2.7 Gya	Eukaryotes
Oxygenic Photosynthesis	2.5 Gya	
Aerobic Respiration	2.2 Gya	
Nitrogen fixing?	?	
Sex	>1.5 Gya	
Multicellularity	>1.2 Gya	multiple times
Vision?	>500 Ma	once? [cf. Walter Gehring]
Land colonization	400 Mya	Amphibians: 345 Mya
Flight	350 Mya	Insects; Pteradactyls; Birds; Bats
Endothermy	250 Mya	Dinosaurs? Birds; Mammals
Flowers, Seeds	150 Mya	

Sociality		insects; mammals
Grasses?	40 Mya	

Evolution of Intelligence

While certain birds and cephalopods are somewhat intelligent, the most intelligent terran organisms are all mammals: Hominoidea, Cetacea, Carnivora, Pinnipedia, and Proboscidea. There are several interrelated factors that correlate with terran intelligence and have probably been mutually reinforcing with it.

- *Dynamic sociality*. The most important contributor to the evolution of intelligence is probably social (as opposed to herd or individual) living with dynamically differential status among individuals. Intelligence aids in recognition of and adaptation to complex and changing social hierarchies, and especially in alliances with and against other groupmates trying to apply their own intelligence.
- *Longevity* allows for amortization of learning costs and enables social memory (culture).
- *Long adolescence* and limited litter size allows time and resources for learning, and reinforces the need for sociality.
- *Large body size* helps support a large and biologically costly brain, and reinforces longevity.
- *Food-chain superiority* (though not necessarily supremacy), often as a predator or else as relative non-prey, contributes to longevity and is contributed to by large size, sociality, and intelligence itself.

What are the precise evolutionary pressures and paths that led to increased intelligence in many mammals and certain birds and cephalopods? There no doubt are limits to how fully humans will ever be able to answer this essentially historical question.

3.5.5.3. Natural Science / Biology / Evolutionary Biology / Taxonomy

Taxonomy: the study of the relationships of organisms.

Taxon	Began	Notes
Prokaryotae (Monera)	3.7G	No nucleus: bacteria.
Archaebacteria		Methanogens; salt, hot acid lovers
Eubacteria		Fermenting; N-fixing; Photo; Chemoauto; Respiring
Protoctista (Protist)	1.2G	Protozoa, amoeba, algae, slime molds. Aquatic.
Chlorophyta		Green algae. Ancestor to Plantae.
...		
Fungi	470M	Spores; no cilia; terran aerobic autotrophs.
Plantae	470M	Embryos, multicellular; usu. photosynthetic, terrestrial.
Bryophyta		Non-vascular; spores. Mosses,
Filicinophyta		Ferns.
Cycadophyta		Palms. Gymnosperm: non-ovarian seeds.
Coniferophyta		Cone-bearing gymnosperm. Pine, fir, spruce, larch,
...		
Angiospermophyta	150M	Flowers, seeds. Fruit. See Insecta, Chordata.

Animalia	700M	Blastula. Multicelled diploid anisogamous heterotrophs.
Parazoa		Indefinite shape, no organs. Sponges,
Eumetazoa		Radial or bilateral symmetry; organs.
Coelenterates		Radial, marine. Hydras, jellyfish, coral, anemone,
...		aquatic worms,
Brachiopoda		Clam-like bivalve shells.
Mollusca		Snails, slugs, oysters, clams, mussels, cephalopods
Arthropoda		Segmented bodies & legs. Crustacea, Insecta,
Echinodermata		Tube feet; radial 5-symmetry. Starfish, urchins,
Chordata		Dorsal nerve, gills. Bilateral.
...		acranial, lacking brain and skull.
Agnatha		No jaws or scales. Lampreys, hagfish, slime eels.
Gnathostomata		Jaws, usually paired appendages.
Pisces		Fishes.
Chondrichthye		Cartilaginous. Sharks, skates, rays.
Osteichthyes		Bony fishes.
Tetrapoda		Four-limbed.
Amphibia		Eggs in water; breathe via skin, gills, lungs.
Reptilia		Dry scaly skin; eggs on land; now cold-blooded.
Aves		Feathers, wings, toothless, warm-blooded.
Mammalia		Warm blood, hair, mammaries.
Prototheria		Egg-laying. Platypus, spiny anteater.
Theria		Non-egg-laying.
Metatheria		Marsupials.
Eutheria		Placental.
Insectivora		Hedgehogs, shrews, moles.
Edentata		Armadillos, anteaters, sloths
Tubulidentata		Aardvark.
Pholidota		Pangolin (scaly anteater)
Rodentia		Squirrels, mice, porcupines,
Lagomorpha		Rabbits, hares.
Hyracoidea		Rabbit-like, hooved: Hyrax
Artiodactylia		Even-toed ungulates: pig deer hippo camel giraffe
Perissodactylia		Odd-toed ungulates: horse zebra rhino
Proboscidea		Elephants.
Carnivora		Dogs, cats, bears,
Cetacea		Whales, dolphins.
Pinnipedia		Seals, sea lions
Sirenia		Sea cow, dugong, manatee
Chiroptera		Bats.
Dermoptera		Colugo (flying lemur)

Primates		Lemurs, tarsiers, monkeys, apes, hominids.

Genetic evidence indicates that many taxa originated earlier than the fossil record suggests. For example, the chordate-arthropod divergence is estimated at 993 ± 46 Mya, and the divergance of plants, animals and fungi is estimated at 1576 ± 88 Mya [Wang, 1999].

3.5.6. Natural Science / Biology / Anthropology

Anthropology: the study of humans as animals.

Primate Taxonomy

Primates are mammals that have grasping appendages with nails not claws, and that use sight more than smell.

Prosimians	Lower primates: lemurs, lorises, tarsiers
Anthropoidea	Infraorder of higher primates
Platyrrhini	New World. separated nostrils; long prehensile tails
Callitrichidae	Marmosets, tamarins
Cebidae	South American monkeys other than marmosets
Catarrhini	Old World. close-set nostrils; nonprehensile or absent tail
Cercopithecidae	African and Asian monkeys: baboons, ..
Hylobatidae	lesser apes: siamangs, gibbons
Hominoidea	Tailless, large, flat-faced, tree-climbing superfamily
Pongidae	great apes: orangutan, gorilla, chimpanzee, bonobo
Hominidae	Small canines, large brains. Bipedal, E. of African Rift Valley.
Australopithecus	Southern ape-man. Africa 5 Mya - 1.5 Mya
Homo	Tools, culture, meat scavenging
habilis	Handy man. Africa 2 Mya
erectus	Africa 2 Mya - 300 Kya. Fire. Into Eurasia. Became sapiens?
sapiens	Vertical forehead, 1350 cc cranium, projecting chin
neanderthalensis	Europe 500 Kya - 30 Kya, when sapiens sapiens arrived. Burial.
sapiens	orig. African pop split 140 Kya, left Africa 50 Kya

Chimps are more closely related to humans than to gorillas. Similarly, chimps and gorillas are more closely related to humans than to orangutans. Thus the clade Pongidae is paraphyletic.

Human Taxonomy

Negroid	Sub-Saharan Africa
Pygmy	Congo R. Pop. 200K. Now speak Bantu.
Black	Nilo-Saharan & Niger-Congo, incl. Bantu expansion
Khoisan	Namibia
Khoi	"Bushmen"
San	"Hottentot"
Caucasoid	N. Africa, SW Asia, India, into Europe 8 Kya

Indian	
European	
Mediterranean	
Basque	Related to pre-Caucasoid Paleo-europeans?
Slavic	
Alpine	
Nordic	
American	Reached America by 13 Kya
Amerind	No type B blood.
Na-Dene	
Eskimo	Reached America 5 Kya. Pop. 130K.
N. Mongoloid	NE. Asia
Han Chinese	
Tibetan	
Mongolian	
Korean	
Japanese	
Ainu	
S. Mongoloid	SE. Asia
SE Asian	
Austronesian	Expanded from Taiwan 3 Kya
Australoid	Reached New Guinea, Australia 40 Kya.
Melanesian	New Guinea, etc.

Evolution of Hominid Intelligence

How did hominid intelligence evolve? This question may never have a fully satisfying answer. It is unlikely that tool use led to bipedality, since the fossil record shows bipedality preceded larger brains and the earliest tools. Bipedaliy was more likely a response to the change of East Africa's climate from forest to savanna, where brachiating is less important than seeing over high grasses. Decreasing sexual dimorphism suggests more-monogamous pair-bonding, and supplemental male provisioning of nuclear families may have co-developed with bipedality. Concealed female ovulation and continual female sexual receptivity both probably contributed to increased male-male cooperation and tighter pair bonding. Such changing social patterns probably increased the selective pressure for intelligence, as did the availability of the hands for tool use following bipedality. The parallel increase in tool use and the size of the metabolically expensive brain was associated with a more omnivorous diet that included scavenging and hunting of meat.

How did Homo sapiens acquire language? This question, too, will likely never have a fully satisfying answer, as the fossil record tells even less about the development of language than it does about the development of intelligence. Just as sociality was crucial to the evolution of intelligence in animals, it probably also created selective pressure for the development of language skills. A variety of particular factors and stages have been proposed.

- Gestural and vocal imitation and miming
- Object and action reference by association through pointing or miming, perhaps motivated by the cooperative or imitative use of tools

- Counting as aiding a transition from iconic to symbolic representation
- Complex neural systems for perception or planned motor control as being adaptable to speech organ control and even syntax production
- Imperatives and interrogatives as earliest sentences
- Planning of future actions and understanding of others' intent as enabling more sophisticated syntactic structures

The result has been neural systems in the human brain that are highly specialized for language.

3.5.7. Natural Science / Biology / Ecology

Ecology: the study of how organisms relate to their environment.

3.5.8. Natural Science / Biology / Exobiology

Exobiology: the study of life beyond the Earth.

4. Technology

Technology: the application of science and mathematics.

1. **Engineering**: the application of physical science.
2. **Biotechnology**: the use of biological and bioactive methods and instruments.
3. **Management**: the direction of persons and related processes.
4. **Industrial Technology**.

4.1. Technology / Engineering

Engineering: the application of physical science.

1. **Materials Engineering**.
2. **Mechanical Engineering**.
3. **Optical Engineering**.
4. **Industrial Engineering**.
5. **Electrical Engineering**.
6. **Electronic Engineering**.
7. **Nuclear Engineering**.
8. **Software Engineering**.

4.2. Technology / Biotechnology

Biotechnology: the use of biological and bioactive methods and instruments.

1. **Agriculture**.

2. **Genetic Engineering**.
3. **Pharmaceuticals**.

4.3. Technology / Management

Management: the direction of persons and related processes.

1. **Administration**.
2. **Finance**.
3. **Marketing**.

4.4. Technology / Industrial Technology

1. **Food Production**.
2. **Sheltering**.
3. **Communication**.
4. **Entertainment**.
5. **Transportation**.
6. **Energy**.
7. **Government**.
8. **Military**.
9. **Education**.
10. **Health Care**.
11. **Manufacturing**.
12. **Merchandising**.
13. **Brokering**.
14. **Services**.

5. Social Science

Social Science: the study of the regular behavior of persons.

1. **Economics**: the study of production, exchange, and consumption of goods by persons.
2. **Political Science**: the study of the government of persons.
3. **Sociology**: the study of human group behavior.
4. **Psychology**: the study of mind.
5. **Linguistics**: the study of language.
6. **History**: the study of humanity's past.
7. **Futurology**: the study of humanity's future.

5.1. Social Science / Economics

Economics: the study of production, exchange, and consumption of goods by persons.

1. **Macroeconomics**.
2. **Microeconomics**.

Fundamental Concepts

Economic value is utility or desirability to persons, especially as determined by free markets. **Goods** are anything which has economic value. The **economic cost** of a good is the economic value of the goods and resources expended to produce it. **Economic efficiency** is economic value divided by economic cost.

Production is the transformation of economic resources into goods. **Economic resources** are any natural resources, human resources, or capital resources that are useful for production. **Capital** is any product that is has utility for production. Human **resources** are the labor, skills, and knowledge of persons.

Exchange is the trading of goods for money or for other goods. A **market** is any mechanism for buyers and sellers to exchange goods. A **free market** is a market in which buyers and sellers are generally free to decide what to exchange and under what terms. **Money** is anything generally accepted as a medium of exchange and thus useful for storing or measuring economic value. The **price** of a good is the amount of economic value that must be exchanged to acquire it. **Demand** is willingness and ability to buy. **Supply** is availability and proffer for sale. The **scarcity** of a good is the excess of its demand over its supply, and in a free market is measured by price.

Consumption is any use of goods that subtracts from wealth without adding to production. **Wealth** is the economic value of what one owns minus what one owes. **Income** is change in net wealth plus the value of goods consumed.

Assumptions and Idealizations

Assumptions. Goods and resources tend to be scarce. Economic actors tend to choose rationally to maximize wealth. In particular, producers choose to maximize profits, and consumers choose to maximize utility.

Idealizations. Producers and consumers have complete information about the prices and quality of all goods available or demanded in the market. Markets for particular kinds of goods are not dominated by a relatively few sellers or buyers. Sellers are able to exclude potential buyers from consuming the sellers' goods without buying them. Under perfect competition, markets tend toward equilibrium. Mathematical proof has been given of the theoretical existence of at least one set of prices that will clear all markets simultaneously.

Principles

The **law of demand** states that the price of a good is inversely proportional to the quantity demanded. The **law of supply** states that the price of a good is proportional to the quantity demanded. The **law of diminishing marginal utility** states that the amount of marginal utility derived from a good diminishes with the amount consumed of that good. The principle of **comparative advantage** states that overall efficiency is maximized if market participants import the products they make least efficiently and export the products they make most efficiently, even if those products are made more efficiently by other participants.

Free Markets. Free trade benefits all parties, even those absolutely more efficient than others. Routine consensual transactions are positive sum, because if either party suffered a loss then she would decline to make the transaction routine. Free markets are the most efficient way to determine the allocation of economic resources and the distribution of goods. The decentralized mechanism of free market pricing is able to ration goods and resources more efficiently than could any central planning agency. This is because the pricing system transmits information about supply and demand more efficiently than could any planning agency. The pricing system forces economic actors to reveal their demand, and forces firms to supply only what is demanded.

Natural resources over time become less costly and thus less scarce. Population growth leads to increased specialization, increased productivity, increased living standards, and a cleaner environment.

Misunderstandings

Thomas Malthus (1766-1834) wrote in his 1798 *Essay on the Principle of Population* that geometric population growth would overwhelm arithmetic growth in agricultural output and thus doom humanity to subsistence living. Malthus was wrong for two reasons. 1) Technological advances have slowed population growth by turning children into net consumers for their family instead of net producers. 2) Technological advances have increased agricultural output faster than population has increased.

Marxism is the belief in the labor theory of value and its consequent conclusion that any profits by private owners of capital are unjustified and exploitive. The **labor theory of value** states that the value of a good is precisely the amount of labor required for producing it. The labor theory of value ignores the fact that capital contributes to value by making labor more productive.

5.1.1. Social Science / Economics / Macroeconomics

Inflation is any increase in overall prices. **Deflation** is any decrease in overall prices. The **real interest rate** is the difference between the nominal interest rate and inflation. Inflation over the long term is not caused by excess demand, or production being close to capacity, or inflationary expectations. Inflation over the long term cannot be "wrung out" of the economy through higher unemployment. Inflation (and deflation) over the long term can only be caused by the money supply growing (or shrinking) relative to aggregate output. Inflation is a tax on dollar-denominated assets, and also transfers wealth from creditors to debtors.

Gross domestic product is the market value of the total production in a year of all the factors of production located in a nation. **Gross national product** is the total production in a year of all the factors of production owned by a nation. The Gross World Product in 1999 was estimated to be $40.7 trillion. Total human wealth has been estimated at $500 trillion. **Recession** is any decrease in gross domestic product that lasts at least six months. Depression is any recession so severe that GDP drops at least 10%. **Growth** is any increase in gross domestic product. Growth is caused by increases in any or all of: capital stock, capital efficiency, labor supply, or labor productivity.

How can real (as opposed to nominal) production and productivity be accurately measured over the long term?

Knowledge and technology can create qualitative improvements in goods and services that confound historical comparisons of real production.

Unemployment is the state of unsuccessfully seeking to sell labor. **Frictional unemployment** is the amount of short-term unemployment caused by the process of matching jobs with job-seekers. **Structural unemployment** is the amount of long-term unemployment caused by long-term changes in the mix of job skills demanded by employers. The **natural rate of unemployment** is the sum of the frictional and structural unemployment rates.

Why is unemployment in industrialized economies often closer to 10% than to what many economists believe should be its natural rate of 1% to 3%?

The most likely explanation is some kind of ratchet effect that keeps wages from falling when demand for labor decreases, so that unemployment substitutes for wage cuts. There are perhaps sociological reasons why employers and employees are reluctant to see wages cut. Also, minimum wage laws probably cause some of the unemployment of low-productivity workers.

The three major markets in the economy are those for goods, labor, and money.

- **Aggregate output** (**Y**) is the total real (i.e. not nominal) market value of all production during a given period, and is equal to the total income: **C** + **S** + **T**.
- **Disposable income** ($\mathbf{Y_d}$) is aggregate income minus net taxes: **Y** - **T**.
- **Aggregate consumption** (**C**) is the total real (i.e. not nominal) market value of all consumption during a given period.
- **Aggregate savings** (**S**) is aggregate output minus aggregate consumption: **Y** - **C** - **T**.
- **Government spending** (**G**) is total government expenditures.
- **Net taxes** (**T**) is total tax receipts minus government transfer payments to households.
- **Net exports** is exports (**EX**) minus imports (**IM**).
- **Planned investment** (**I**) is the intended aggregate creation of capital.
- **Planned aggregate expenditure** (**AE**) is aggregate consumption plus planned investment: **C** + **I** + **G** + (**EX** - **IM**).
- **Marginal propensity to consume** (**MPC**) is the fraction of marginal income that is consumed: $\Delta\mathbf{C}/\Delta\mathbf{Y}$.
- **Marginal propensity to save** (**MPS**) is the fraction of marginal income that is saved: $\Delta\mathbf{I}/\Delta\mathbf{Y}$ or 1 - **MPC.**
- **Marginal propensity to import** (**MPM**) is the fraction of marginal income that is spent on imports**.**

Equilibrium in the goods market is when **AE** = **Y** and **S** + **T** = **I** + **G**.

A **multiplier** is the ratio of the increase in the equilibrium level of aggregate output to the independent increase in some input. The multipliers for planned investment **I** and for government spending **G** are both 1/(1 - **MPC** + **MPM**), which is 1.4 [Case & Fair 1999]. The multiplier for taxation is -**MPC**/**MPS**. The multiplier for an increase or decrease in a balanced government budget is 1.

The **money supply** is the amount of money in circulation, usually measured as M1 or M2. **M1** is all currency held outside banks plus all deposits against which a check may be written. **M2** is M1 plus all

accounts which are easily convertible into currency, such as savings and money market accounts. The **velocity of money** is the ratio of nominal GDP to the money supply.

A **central bank** is the institution in a nation that creates currency, regulates the money supply, and stabilizes the banking system. The **required reserve ratio** is the fraction of any bank's deposits that must be held at the nation's central bank. Banks are able to create money by making loans, but only if they have reserves in excess of the required reserve ratio. The money multiplier is the ratio of increase in money supply to increase in reserves.

5.1.2. Social Science/ Economics / Microeconomics

1. **Market Theory**.
2. **Market Imperfections**.
3. **Public Policy**.

5.1.2.1. Social Science / Economics / Microeconomics / Market Theory

An **industry** is the market for a particular kind of good. A **firm** is an organization of persons under unified management trying to maximize profit by producing goods to meet perceived demand. **Profit** is total revenue minus total cost. **Pure rent** is the return to any production factor that is of fixed supply. **Sunk costs** are costs already incurred. **Fixed costs** are costs that are constant for a given level of production. **Variable costs** are costs that are a function of the level of production. **Marginal cost** is the cost of producing one more unit of output.

The **law of diminishing returns** states that applying additional units of a production factor out of proportion to other production factors will eventually yield smaller increases in production. Additional capital increases the productivity of labor, which increases the demand for labor, which increases the price of labor (wages). The equilibrium price of (and return to) each production factor is equal to its productivity as measured by marginal revenue product. Thus the standard of living for laborers is ultimately determined by the productivity of labor.

The **short run** is the time scale on which there is a fixed scale of production and no entry or exit of firms from the market. The **long run** is the time scale on which firms can enter or exit markets and scale production as they choose. The **productivity** of a production factor is the amount of its output per unit input. The **marginal revenue product** of a variable production factor is the additional revenue earned by employing an additional unit of that factor. **Investment** is the creation of new capital. **Depreciation** is the decline in an asset's value over time, due usually to accumulated use or obsolescence. The **present discounted value** of receiving return **R** after time **t** at interest rate **r** is $\mathbf{R} / (1+\mathbf{r})^{\mathbf{t}}$.

Speculation is the buying and selling of goods, and especially factors of production, with the intent of profiting from their changing market value over time. Speculation performs the socially useful function of targeting investment to the production factors that are most productive. Even short-term speculation performs this role, because short-term speculators must determine the net present value as it will be perceived in the near future, which recursively depends on the long-term net present value.

Pareto optimality is the condition that obtains when no person can be made more happy without making some person less happy.

5.1.2.2. Social Science / Economics / Microeconomics / Market Imperfections

Violations of the various assumptions about markets can lead to misallocation of resources. **Excludability** is the ability of producers to detect and prevent uncompensated consumption of their products. **Rivalry** is the inability of multiple consumers to consume the same good.

- **Monopoly** is the condition of any industry in which production is controlled by a small number of producers and for which entry by new producers is difficult. A **natural monopoly** is any industry with high fixed cost and continuously declining average costs for any producer.
- **Externality** is a cost imposed or benefit bestowed on a person other than those who agreed to the transaction that created the cost or benefit. Negative externalities are costs such as pollution or overconsumption of natural resources. Positive externalities are benefits such as scientific discoveries and incremental technical advances.
- **Public goods** are non-rival non-excludable positive externalities, such as national defense and other duties of the state, that benefit essentially every person in a society. The pricing system cannot force consumers to reveal their demand for non-excludable goods, and so cannot force producers to meet that demand.
- **Imperfect information** is the unavailability of complete information about the prices and quality of all goods available or demanded in the market. **Adverse selection** is misallocation of resources caused by transactions among parties with differing amounts of relevant information, such as when sellers know more about products than buyers. **Moral hazard** is any case in which a contract shields a person from the consequences of their decisions and thus encourages the wrong decisions.

The **Coase theorem** states that markets will allocate resources and production efficiently even in the case of externalities if a) all the relevant rights are clearly (even if unfairly) assigned, and b) transaction costs of negotiation are minimal. The **Tiebout hypothesis** is that public goods can be produced efficiently if produced locally, so that their price (in the form of local taxes and land values) reflects the preferences of consumers free to choose where they live.

5.1.2.3. Social Science / Economics / Microeconomics / Public Policy

Taxes can be levied on either static holdings or dynamic transactions. Static taxes are of two major kinds.

- *Wealth and property taxes* can grow to be confiscatory and impose hardships on owners of illiquid assets.
- *Capitation taxes* completely disregard ability to pay.

Transaction taxes include several kinds.

- *Income taxes* can be used for income redistribution, especially if a negative tax bracket is included.
- *Consumption taxes* can encourage investment but tend to be regressive unless moderated by a personal exemption.
- *Production taxes* (like value-added taxes) can be complex to administer and difficult to use as policy tools.
- *Resource use and access taxes* may not be as efficient as allowing property rights in resources. This applies, for example, to the tax proposed by Henry George (1839-1897) on pure economic rent.
- Fees are in theory ideally fair and efficient, but in practice are difficult to assess for public goods. Contract insurance is a proposed way to finance state operations directly from fees on its

fundamental activity of enforcing contracts.

An income tax is a double tax on saving. The benefit that flows from income consumed is taxed once, while the benefit that flows from income saved is taxed again as future income. After a given amount of income has been earned, consuming it incurs no further tax, while saving it does.

The labor supply in an economy like America's is inelastic, in that the labor supply does not change much when wages change. Thus payroll taxes levied on employers are actually paid by employees, because they will generally still work for wages lowered by the tax. If the labor supply were elastic, then employers would have to raise wages by the amount of the tax in order to keep their labor supply.

Minimum wage laws tend to increase unemployment among low-wage earners by over-pricing their labor and thus decreasing the demand for it. The social benefit of a minimum wage is financed through a hidden and production-distorting tax that falls on only certain goods and services rather than on the general tax base. Unions with monopolistic control over the labor supply in a particular industry enforce artificially high wages that lead to suboptimal levels of production and employment. Rent control prevents the supply of housing from expanding to meet the demand, and transfers income from those unlucky enough to be landlords to those lucky enough to have a(n increasingly scarce) lease.

5.2. Social Science / Political Science

Political Science: the study of the government of persons.

1. **Roles of Government**.
2. **Political Forces**.
3. **Political Processes**.
4. **Forms of Government**.
5. **Branches of Government**.
6. **Levels of Government**.
7. **Jurisprudence**: the study of laws governing persons.
8. **International Relations**.
9. **World Politics**.

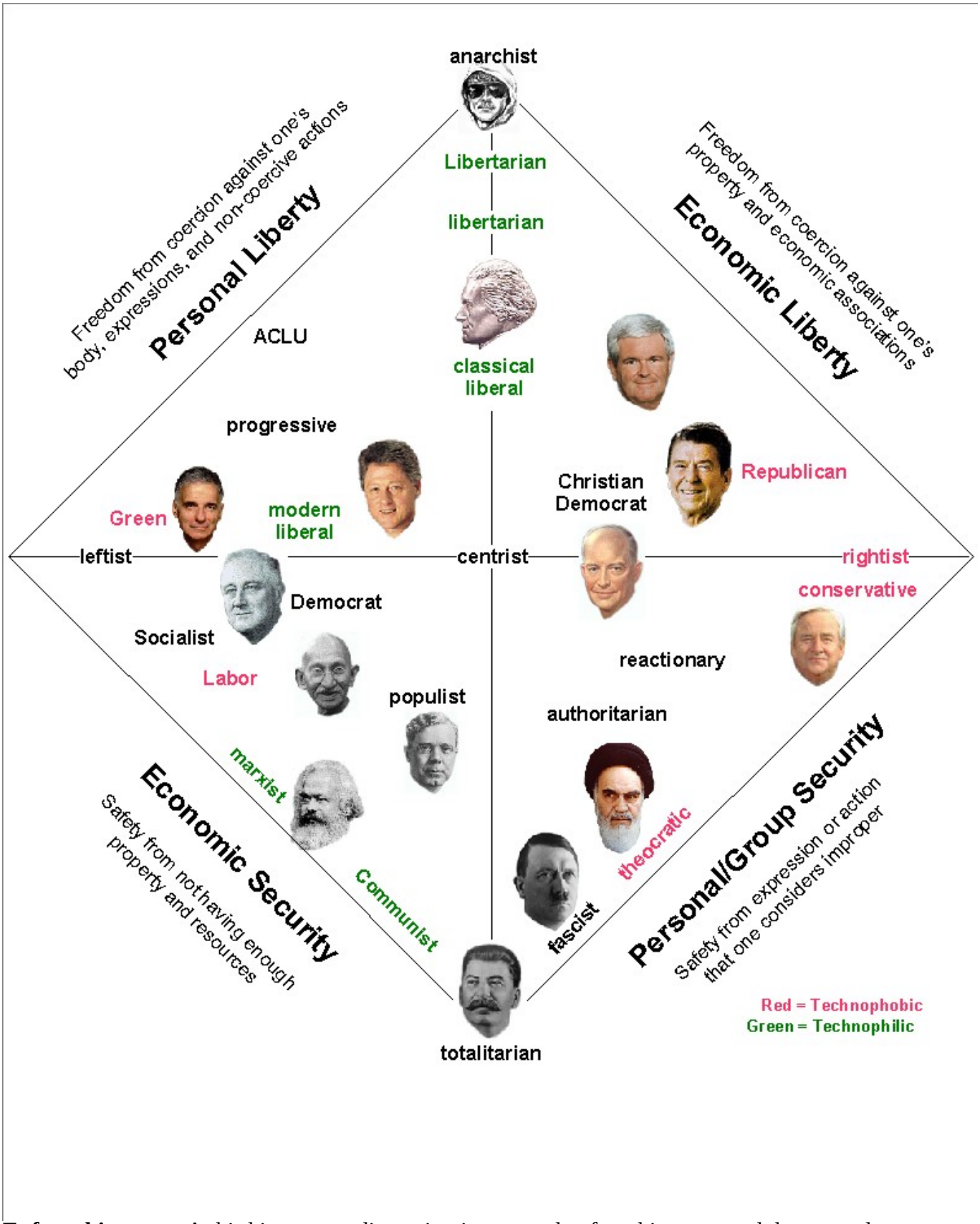
5.2.1. Social Science / Political Science / Roles of Government

5.2.2. Social Science / Political Science / Political Forces

Dimensions of Political Opinion

Economic and Personal Liberty. The two major dimensions of modern human political advocacy are 1) economic liberty vs. security and 2) personal liberty vs. security. Economic liberty is freedom from coercion against one's property or resources. Economic security is safety from not having enough property or resources. Personal liberty is freedom from coercion against one's body, expressions, or

non-coercive actions. Personal security is safety from expression or action that one considers improper.



Enfranchisement. A third important dimension is personal enfranchisement and the general enfranchisement of beings by e.g. sentience or taxonomic endangeredness. **Enfranchisement** is the

recognition of rights by virtue of properties such as sentience, fetal development, age, intelligence, sex, ethnicity, sexuality, religion, property ownership, and citizenship. **Discrimination** is the unfair treatment of persons based on their possession of the properties involved in personal enfranchisement.

In theory this third dimension is independent of the first two, but in practice it correlates (imperfectly) with the personal liberty vs. security axis. The two sorts of enfranchisement for which the correlation is weakest are fetal status (see Pro-Choice) and citizenship. Favoring enfranchisement of non-citizens implies support for free trade, liberal immigration, foreign aid, human rights abroad, and humanitarian interventionism (as opposed to isolationism or imperialism). Foreign intervention has historically been imperialist rather than humanitarian, and so doves have usually been progressives, and hawks have usually been reactionaries.

Misunderstandings

"Pro-Choice". Many otherwise progressive thinkers subordinate any consideration of a fetuses' franchise to the liberty of women to control what happens inside their skin. These self-styled progressives would never subordinate a slave's (or trespasser's) franchise to the liberty of plantation owners to control what happens inside their fence lines. The inconsistency seems more of an emotional over-reaction to the recent non-enfranchisement of women at the hands of men, and less of a clear-eyed decision to draw the line of franchise at e.g. birth or fetal viability. Such a naked assertion of women's entrenched interest over that of fetuses, *without* due consideration and explicit rejection of fetal franchise, is hardly progressive but rather plainly reactionary.

Thus being "pro-choice" on abortion is as disingenuous as being "pro-choice" on slave-owning. The position actually being advocated is the non-personhood of fetuses and slaves, respectively. But "No personhood for fetuses" is not a very fun bumper sticker, and so opponents of fetal personhood choose to obscure the real issue.

5.2.3. Social Science / Political Science / Political Processes

5.2.4. Social Science / Political Science / Forms of Government

Governments vary by who wields power:

- Anarchy
- Democracy
- Republic
- Oligarchy
- Autocracy
    - Monarchy

Governments vary by how much power is wielded:

- liberal
- authoritarian
- totalitarian

Governments vary by how their power is justified:

- democracy
- theocracy
- aristocracy
- tyranny

Civilians Killed by Governments in the Twentieth Century [R.J. Rummel *Death By Government*, 1994]

Location	Regime	Deaths	Era
Soviet Union	Communists	61,900,000	1917-1990
China	Communists	35,200,000	1949-1994
Germany	Nazi Third Reich	20,900,000	1933-1945
China	Kuomintang	10,400,000	1928-1949
Japan	Imperial-Fascist	6,000,000	1936-1945
China	Communist Guerrillas	3,500,000	1923-1948
Cambodia	Communists	2,000,000	1975-1979
Turkey	"Young Turks"	1,900,000	1909-1917
Vietnam	Communists	1,700,000	1945-1994
North Korea	Communists	1,700,000	1948-1994
Poland	Communists	1,600,000	1945-1948
Pakistan	Yahya Khan	1,500,000	1971
Mexico	Porfiriato	1,400,000	1900-1920
Yugoslavia	Communists	1,100,000	1944-1990
Russia	Czarist	1,100,000	1900-1917
Turkey	Mustafa Kemal "Ataturk"	900,000	1918-1923
United Kingdom	Constitutional	800,000	1900-1994
Portugal	Fascist	700,000	1926-1975
Croatia	Fascists	700,000	1941-1945
Indonesia	Suharto	600,000	1965-1994

5.2.5. Social Science / Political Science / Branches of Government

5.2.6. Social Science / Political Science / Levels of Government

5.2.7. Social Science/ Political Science / Jurisprudence

Jurisprudence: the study of laws governing persons.

5.2.8. Social Science / Political Science / International Relations

5.2.9. Social Science / Political Science / World Politics

American Political Parties

The **Democratic Party** is the populist American political party which was founded in 1792 by Thomas Jefferson, which supported state's slavery rights before the Civil War, and which was refocused by

Franklin Roosevelt toward leftist policies of welfare statism, civil rights and economic equality. As leftists, Democrats are more likely to favor economic security over economic liberty, but personal liberty over personal security. Democrats are more likely to prefer centralized federal solutions over local, private or market solutions. Democrats are less likely to trust free markets to be efficient and fair, and thus are less likely to trust individuals with economic freedom. Late 20th-century Democrat constituencies include blacks, Jews, organized labor, hispanics, the poor, gays, urbanites, and women. Late 20th-century Democrat policies are as follows.

- International Freedom and Security
  - Defend American strategic interests. *Oppose 2-war conventional capability* and 1st-strike nuclear weapons.
  - Oppose totalitarianism and authoritarianism.
- Governance
  - Establish republican democracy with equal representation for all persons. *Limit campaign contributions and spending.*
  - *Ignore Art 1 Sec 8 enumeration of federal powers.*
  - Ban government discriminationagainst persons. *Disallow personhood for viable fetuses.* Prevent government endorsement of religion. Allow gay marriage and military service.
  - Preserve species and ecosystems. Prevent animal torture. Conserve public lands.
  - *Inflate money supply in hopes of lower unemployment (at the risk of higher inflation).*
  - *Tax 40-70% of high incomes and wealthy estates.*
  - *Oppose mandatory balanced budgets,* support line-item veto.
- Personal Freedom and Security
  - Prevent coercion, enforce contracts, and protect free personal association, *with the following exceptions*.
  - *Ban discrimination in non-economic semiprivate association (e.g. clubs).*
  - *Limit or punish "hateful" (pro-discrimination) speech, especially if connected with crime. Mandate content-screening technology and related categorization of expression. Limit technology for encoding and decoding information.*
  - *Ban almost all prostitution, gambling, and psychotropics (except alcohol, nicotine, and caffeine). Mandate self-protection practices such as seat belt and helmet use.*
  - *Ban cloning, and sale or hire of reproductive tissue or services.*
  - Ban private ownership of military weaponry. *Mandate purchase waiting periods, registration, and locks for gun owners.*
- Economic Freedom
  - Regulate natural monopolies: roads, water/sewer/power/phone/cable lines. Regulate anti-competitive artificial monopolies. Regulate incorporation and bankruptcy.
  - Otherwise protect non-coercive economic association, *with the following exceptions*.
  - *Ban discrimination in economic association. Mandate preferences to redress past or current discrimination.*
  - *Regulate economic association between parties with unequal economic power or information.*
    - *Mandate minimum wage, maximum hours, unemployment insurance, plant closure*

notice, family leave, "equal pay for equal work", employee training. Allow union monopolies, mandatory union membership. Ban permanent replacements for strikers.

- *Mandate professional licensure, product safety, rent control, building codes.*

- *Mandate zoning and growth control.*
- *Tax and ban imports that compete with domestic production or damage foreign ecosystems.*

- Economic Security
  - *Mandate per-artifact pollution controls and fuel economy regulations.* Tax greenhouse gas emissions.
  - *Aid unwed mothers, disabled workers, workers' survivors. Provide food stamps and school lunches to the indigent.*
  - *Mandate a socialized pyramid scheme for retirement: Social Security.*
  - *Socialize most elementary and secondary schools and many colleges.*
  - *Socialize health insurance and many hospitals. Regulate healthcare and drug prices.*
  - *Subsidize agriculture (including tobacco). Regulate much of commodity production and prices.*
  - *Subsidize some energy production. Regulate many energy prices.*
  - *Public ownership of postal service, airports, local transit, low-income housing, some broadcasting stations.*

The **Republican Party** is the American political party which was founded in 1854 to oppose slavery and preserve the federal union, and which advocates rightist policies of economic freedom and personal security. Republicans are less likely to prefer centralized federal solutions over local, private or market solutions. Republicans are more likely to trust free markets to be efficient and fair, and thus are more likely to trust individuals with economic freedom. Late 20th-century Republican constituencies include fundamentalist Christians, the wealthy, asians, suburbanites, and men. Late 20th-century Republican policies are as follows.

- International Freedom and Security
  - Defend American strategic interests. Create 2-war conventional capability *and 1st-strike nuclear weapons.*
  - Oppose totalitarianism and authoritarianism *but tolerate anti-totalitarian authoritarianism*.

- Governance
  - Establish republican democracy with equal representation for all persons. Mandate disclosure of all campaign contributions.
  - Limit federal powers to Art 1 Sec 8 enumeration.
  - Ban government discrimination against persons. Allow personhood for *even pre-viable* fetuses. *Allow token government endorsement of Abrahamic religion. Ban gay marriage and military service.*
  - Preserve species and ecosystems. Prevent animal torture. Conserve public lands.
  - Increase the money supply only as fast as GDP grows.
  - Flatten income taxes. Repeal estate taxes.
  - Mandate balanced budgets, support line-item veto.

- Personal Freedom and Security
  - Prevent coercion, enforce contracts, and protect free personal association*, with the following exceptions*.
  - *Mandate content-screening technology and related categorization of expression. Limit technology for encoding and decoding information.*
  - *Ban almost all prostitution, gambling, and psychotropics (except alcohol, nicotine, and caffeine). Mandate self-protection practices such as seat belt and helmet use.*
  - *Ban cloning, and sale or hire of reproductive tissue or services.*
  - Ban private ownership of military weaponry. *Limit Miranda exclusionary rule.*
- Economic Freedom
  - Regulate natural monopolies: roads, water/sewer/power/phone/cable lines. Regulate anti-competitive artificial monopolies. Regulate incorporation and bankruptcy.
  - Otherwise protect non-coercive economic association*, with the following exceptions*.
  - *Ban discrimination in economic association.* Oppose preferences to redress past or current discrimination.
  - *Regulate some economic association between parties with unequal economic power or information.*
    - *Mandate minimum wage, maximum hours, unemployment insurance.*
    - *Mandate professional licensure, product safety, building codes.*
  - *Mandate zoning.* Protect property rights against growth controls.
- Economic Security
  - Mandate market-based incentives for pollution control.
  - *Aid unwed mothers, disabled workers, workers' survivors. Provide food stamps and school lunches to the indigent.*
  - Mandate private retirement savings by privatizing *part of* Social Security.
  - Provide vouchers for parental choice of primary and secondary school.
  - *Streamline patient appeals of health insurance decisions. Continue two-tiered socialized health insurance for seniors and the indigent*. Provide a tax credit for purchase of private health insurance.
  - *Subsidize some energy production. Promote oil and gas exploration on federal lands.*
  - *Public ownership of postal service, airports, and local transit.*

The **Libertarian Party** is the American political party founded in 1971 to promote personal freedom and responsibility by limiting the state to only prevent force and fraud. Late 20th-century Libertarian policies are as follows.

- International Freedom and Security
  - Defend America's borders *and practice isolationism.* Ban military conscription.
  - Allow immigration *without regard for linguistic or economic proficiency.*
- Governance
  - Establish republican democracy with equal representation for all persons.
  - Ban government discrimination against persons. *Disallow personhood for viable fetuses.* Prevent government endorsement of religion. Allow gay marriage and military service.

        - Privatize *all* natural resources *including all government-owned land.*
        - *Abolish regulation of money and currency.*
        - *Replace all income and property taxes with other unspecified taxes and fees.*
        - Mandate balanced government budgets. Eliminate most government spending, except on enforcement of laws against force and fraud.
- Personal Freedom and Security
    - Prevent coercion, enforce contracts, and protect free personal association.
    - Abolish *all* limits on private ownership of *military* weaponry.
- Economic Freedom
    - Allow all non-coercive economic association. *Repeal all antitrust laws.*
- Economic Security
    - *Rely only on torts to regulate pollution and other externalities.*
    - *Rely only on charity to aid the indigent.*
    - All free markets to manage industries*, including natural monopolies.*

5.3. Social Science / Sociology

Sociology: the study of human group behavior.

5.4. Social Science / Psychology

Psychology: the study of mind.

1. **Sensation**.
2. **Perception**.
3. **Learning**.
4. **Memory**.
5. **Cognition**.
6. **Motivation**.
7. **Cognitive Development**.
8. **Social Development**.
9. **Psychological Disorders**.

5.5. Social Science / Linguistics

Linguistics: the study of language.

Groups in all capitals are ethnogeographic and not linguistic.

```
AFRICAN
  Niger-Congo
    Bantu
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      Xhosa
      Swahili                    Tanzania
      Shona                      Zimbabwe
      Zulu                       S. Africa
      Xhosa                 7M   S. Africa
      ..
    ..
  Nilo-Saharan
  Khoisan                        Namibia: "Bushmen", "Hottentots"
    Hadza, Sandawe               Tanzania!
    ..
SOUTHEAST ASIAN
  Sino-Tibetan
    Sinitic
    Tibeto-Burman
  Austric
    Austronesian
    Tai-Kadai                  Thai, Lao
    Hmong-Mien
    Austroasiatic

      Munda                    NE India
      Mon-Khmer                Vietnamese
  Indo-Pacific
    Melanesian
    New Guinean
  Aboriginal
NORTH EURASIAN
  Basque
  Nostratic
    Afro-Asiatic
      Semitic
        Hebrew
        Arabic
      Cushitic
      Berber
      Chadic
    Kartvelian
    Dravidian
    Eurasiatic
      Altaic
        Turkic
          Turkish
          Uzbek
          Kazakh
          Turkmenian
          Azerbaijani
          ..
        Mongolic
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- Tungusic
  - Manchu ..
- Korean
- Japanese

Uralic
- Finno-Urgic
- Samoyedic
- Yukaghir

Indo-European
- Celtic
  - Brythonic
    - Breton
    - Cornish
    - Welsh
  - Gaelic
    - Irish
    - Scots
    - Manx
- Italic
  - Latin
  - Italian
  - Spanish
  - Portugese
  - French
  - Provencal
  - Romanian
  - Rhaeto-Romance
- Greek
- Germanic
  - West
    - English
    - Frisian
    - German
    - Dutch
    - Afrikaans
    - Yiddish
  - North
    - Danish
    - Norwegian
    - Swedish
    - Icelandic
    - Faroese
- Balto-Slavic
  - Baltic
    - Lithuanian
    - Latvian
  - Slavic
    - West
      - Polish

```
              Czech
              Slovak
              Sorbian
            South
              Bulgarian
              Macedonian
              Serbian/Croatian
              Slovenian
            East
              Russian
              Belarusian
              Ukrainian
        Armenian
        Albanian
        Tocharian
        Anatolian
        Indo-Iranian
          Indic
            Sanskrit
            Hindi, Urdu
            Sinhalese
            Nepali
            Bihari
            Bengali
            Romany
          Iranian
            Persian
            Kurdish
            Pashto
            Ossetic
            Baluchi
            Tajik
AMERICAN
  Eskimo-aleut
  Na-Dene
  Aztec-Tanoan
  Mayan
  Carib
  ...
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5.6. Social Science / History

History: the study of humanity's past.

The following history of humanity will supplement traditional political history (who did what) with technological, intellectual, economic, and military history (how and why things were done).

5.6.1. Paleolithic History

Populations of Homo erectus had dispersed from Africa throughout Eurasia beginning around 1.5 or 2 Mya. Some time between 100 Kya and 50 Kya, anatomically modern humans (H. sapiens sapiens) dispersed from Africa and displaced all the other Eurasian hominid populations. These humans were characterized by specialized tools (some of bone), symbolic expression, fishing, better shelters, improved fire control, and burials involving grave goods. It is likely that these dramatic advances were associated with the development of fully human language.

Modern humans spread rapidly from their origins in E. Africa and SW Asia. H. sapiens sapiens arrived in Europe 40 Kya, and by 30 Kya H. neanderthalensis was extinct. Modern humans reached Australia from 60Kya to 40Kya, and apparently caused the extinction of much megafauna there, including the rhino-sized marsupial herbivore Diprotodon.

European humans retreated to southern European refugia during the last glacial maximum (Wurm IV) around 17 Kya. The end of the last ice age led to a recolonization of Europe around 13 Kya.

Farmers (or at least farming) from SW Asia spread into Europe around 8.5 Kya.

- Paleolithic History
  - ice ages, tools, fire, population
  - europe, australia, megafauna, neanderthal, watercraft
  - weaving,
  - ice age, temp, sea level, refugium?, tasmania/australia cut off, lose fire
  - americas, megafauna
- Neolithic Age 8500-3500BCE
  - farming
  - horse, indo-european
- Metals Age 3500BCE-1453
  - Sub-Saharan Africa before colonialism
    - bantu expansion
  - Americas before colonialism
    - Andes
      - Pre-Inca
      - Inca
    - Meso-America
      - Maya
      - Aztec
    - North America
  - Oceania before colonialism
    - austronesian expansion, madagascar
  - East and South Asia before colonialism
    - South Asia
    - China

        - Central Asia
        - Japan
        - Southeast Asia
    - West Eurasia until 1453
        - Southwest Asia until 539BC
            - Egypt
            - Aegean
            - Mesopotamia
            - Palestine
        - Persia 539BC-336BC
        - Greece 336BC-201BC
        - Rome 201BC-330
        - Byzantium and the Huns 330-632
        - Islam and Christendom 632-1206
        - Mongols, Ottomans and the Early Renaissance 1206-1453
- Gunpowder Age 1453-1815
    - Middle Renaissance 1453-1517
    - Reformation 1517-1648
    - Absolutism 1648-1715
    - Enlightenment 1715-1789
    - Nouveaux Regimes 1789-1815
- Machine Age 1815-1945
    - Industrialization 1815-1870
    - Modernization 1870-1914
    - Cataclysm 1914-1945
- Atomic Age 1945-
    - Recovery and Cold War 1945-1989
    - Liberation 1989-

Most Important Advances

Listed below are some of the most important contingent non-parochial revolutionary advances in human history. An **advance** is essentially any change that increases the complexity or capability of a system. Advances increase what is (thought to be) possible. Non-examples are mass extinction and nuclear war. An advance is **contingent** if it might not have happened, and so contingent advancements ought not to happen independently very often. Examples are the formation of particular stars (like the Sun) and planets (like the Earth), or the occurrence of sunrises and sunsets. An advance is **parochial** if it depends on local circumstances and so is not likely to have parallels in other systems. Examples are the European discovery of America and the fall of Communism. An advance is **revolutionary** if its adoption was relatively non-incremental, compelling, and essentially irreversible. Non-examples are democracy and free markets.

Advance	When	Who

Stone Tools	2.5 Mya	
Fire Control	1.4 Mya	
Language	100-50 Kya	
Watercraft	40 Kya	SE Asia 13 Kya: Mediterranean
Food Production	10.5 Kya	
Metallurgy	4000 BCE	Eurasia/China 1500: Andes
Horse Riding	4000 BCE	Central Asia
Writing	3500 BCE	Egypt; Mesopotamia; China; 500 BCE: Maya
Philosophy	600-335 BCE	Thales et al; Aristotle
Mathematics	550-200 BCE	Pythagoras; Euclid; Archimedes; Apollonius
Firearms	1300s	Europe (gunpowder: China 800s)
Movable Type	1454	Gutenburg; 1040: Pi Sheng; 1300s: Korea
Heliocentrism	1543	Copernicus; c250 BCE: Aristarchus
Telescopy, Microscopy	1608	Lippershey, Galileo
Calculus	1666	Newton, Leibniz
Mechanics	1687	Newton
Heat Engine	1712;1769	Newcomen; Watt
Electromagnetics	1831;1864	Faraday; Maxwell
Wire Telecom	1844	Morse; 1876: Bell
Evolution	1859	Darwin, Wallace
Germ Theory	1862	Pasteur
Genetics	1866	Mended; 1953: Watts, Crick
Set Theory	1874	Cantor; 1902: Russell
Radio Telecom	1895;1904	Marconi; Fleming
Powered flight	1903	Wright
Special Relativity	1905	Einstein

General Relativity	1916	Einstein
Quantum Theory	1927	Heisenberg; 1900: Planck; 1928: Dirac
Space flight	1929	Tsiolkovsky; 1957: Sputnik
Big Bang	1929	Hubble; 1948: Gamow et al. 1965: Penzias, Wilson
Incompleteness	1931	Godel; 1937: Turing
Fission	1938	Hahn; Oppenheimer
Computing	1946;1948	Von Neumann; Bardeen et al
Packet Networking	1961	Baran, Davies
Standard Model	1974	1964: Gell-Mann; 1967: Weinberg, Glashow, Salam
(?) String/M Theory	1984	Green, Schwartz

Several important advances are nonetheless either derivative or not quite revolutionary.

- Television is derivative of radio telecommunication. The train and automobile are derivative of the heat engine.
- Economic theory has been important but largely cumulative instead of truly revolutionary. There was no single invention of money. The first corporation was as early as 1602. Theoretical work by Smith (1776), Marx (1848), Keynes (1936), and Friedman (1963) was important but never completely compelling.
- Political theory too has been important but largely cumulative instead of truly revolutionary. Developments in Greece, Rome, England, and America were often literally revolutionary but rarely compelling in the sense that knowledge, opinion, or practice would henceforth never be quite the same.
- Mathematical logic was synthesized in the late 1800s and early 1900s by workers like Boole, Frege, Peano, Cantor, Russell, Zermelo, and Godel. The cumulative impact of mathematical logic has been revolutionary, and includes both the constituent revolutions of Cantor's Set Theory and Godel's Incompleteness. However, for the larger programme of mathematical logic, no single year or worker can be used to mark its beginning or turning point.

5.7. Social Science / Futurology

Futurology: the study of humanity's future.

1. **Impossible Advances**.
2. **Improbable Advances**.
3. **Academic Developments**: the trends and changes in what humans know.
4. **Technological Developments**: the trends and changes in what humans know how to use.

5. **Industrial Developments**: the trends and changes in how humans carry out their activities.
6. **Sociopolitical Developments**: the trends and changes in how humans behave.
7. **Challenges**.
8. **Possible Catastrophes**.
9. **Timeline**.

Future History

Humanity will enjoy increasing political and economic liberty, as well as increasing freedom from ignorance and superstition. Humanity will enjoy increasing prosperity and steady progress within the limits defined by the laws of physics. Effective immortality may result from technology allowing avhuman mind to sustain its brain or perhaps transform itself into an intelligent artifact. Human civilization will experience neither salvation nor extermination by nature, machines, aliens, or gods. Humanity will spread throughout the Solar System and into the Milky Way, and be enriched by contact with other intelligent species and artifacts. Eventually humanity's descendants will so improve their genes and minds that Homo sapiens will exist primarily as a revered memory.

Technological Revolutions

The long-term history and fate of humanity is driven almost entirely by technology. There have been five great technological revolutions in hominid history, and one or two others are faintly visible on the horizon.

Tools. The penultimate great biological advance on Earth was the evolution of hominid intelligence. This led directly to the hominids' first great technological revolution at the beginning of the Paleolithic Age by 2 Mya: the use of stone tools and (later) fire. Tools and fire granted to hominids a mastery over predators, prey, and the elements that was literally unimaginable to other primates.

Language. The second technological revolution was also the most recent great biological advance on Earth: the development of language by 50 Kya. The development of language, watercraft, and weaving combined to allow early modern humans from Africa and SW Asia to master climates and locales throughout the world.

Agriculture. The third revolution was the development of agriculture at the beginning of the Neolithic Age about 10 Kya. The resulting specialization led to the advanced development of writing, government, and science.

Industry. The fourth revolution was the Industrial Revolution that was under way by 1840. It included the development of heat engines, medicine, electromagnetics, and (later) atomics. The Industrial Revolution was of course only possible because the Scientific Revolution that began during the Renaissance. However, it was not until the Industrial Revolution that living standards finally made a leap to levels that would have been unimaginable to Aristotle or even Newton.

Information. The fifth revolution is the current Information Revolution. It had started by 1971 with the development of electronics, computing, and networking, which together had major impacts on commerce and communications by the 1980s and 1990s. The Information Revolution will continue with the nascent developments of photonics and genetics. It will largely complete the liberation of humanity from tyranny and superstition. It will witness the completion of humanity's basic understanding of the origin, mechanism, and fate of mind, life, and the universe itself.

Generation. By about 2200 a sixth revolution will be under way, driven by some combination of:

- genetic engineering of new subspecies;
- commercialized controlled fusion;
- nanotechnology;
- artifactual life; and
- artificial intelligence.

This revolution will establish the economics of the indefinite future. Design, energy, and heat costs will be the only ones that really matter, and no future breakthroughs will ever fundamentally reduce them again. During this phase of history, the various human societies will arrive at economic, cultural, and linguistic parity and unity.

Homogenetics. By about 3000, modifications to the human genome will no longer be confined to changing the frequency or expression of existing genes, but will include the design of new genes. This will ultimately transform humanity into a new and improved species.

Automentation. After engineering the human genome, the next (and perhaps last) technological revolution will be to engineer the (human?) mind. The first step will be the creation of neurological interfaces between human brains and computing devices. Another step might be the (perhaps neuron-by-neuron) replacement of some brain components with improved artificial parts. Or, it may be possible for a person to gradually offload mental processing from her brain to her computational prostheses. Perhaps eventually she could dispense with her fragile mortal brain altogether, so as to gain immortality while still preserving personal identity.

Misunderstandings

Estimating Progress. The modern idea of Progress arose in the Enlightenment. In the subsequent few centuries, prognosticators almost always underestimated future progress. Only towards the end of the miraculous period of advances from 1859 to 1945 did futurologists consistently start overestimating future progress.

The **Doomsday Argument** is the thesis that the future of humanity may be relatively short because a human randomly sampled from all humans who ever will have lived is more likely to be middling in birth rank than early. `In the absence of other information about humanity's prospects, the Doomsday Argument would be significant. In the presence of almost any such information, the Doomsday Argument is irrelevant.`

5.7.1. Social Science / Futurology / Impossible Advances

Divine Salvation. Humans will never experience either collective or individual salvation by any divine or supernatural agency.

Paranormality. The paranormal phenomena alleged in 2000 by many humans will never prove to be real and will over time be recognized as delusions, hysteria, myths, nonsense, and hoaxes.

Reanimation. There will never be any reanimation of humans whose brains have suffered

any of the degradation that occurs at normal temperatures when metabolism ceases. Human personalities may someday be crudely simulated, but such simulations will never have significant fidelity and would not in any event have the identity of the simulated personality.

Explanation of Somethingness. Humans will never have a definitive answer to the question of why there is something rather than nothing. Humans may, however, eventually be able to show that no definitive explanation of existence is possible.

Superluminal Communication. There will never be a way to travel or communicate through space at speeds greater than that of light. Nor will there be a way to warp spacetime to circumvent this restriction.

Temporal Travel. There will never be a way to travel or communicate backwards in time. While time travel is not explicitly impossible under the known laws of physics, the proposed wormhole mechanism for it would require energies and technologies that are simply not achievable. Note also that a wormhole time machine would not allow travel back to before the wormhole was created.

Teleporter Travel. There will never be a way for humans to travel via transmission of information describing their physical constitution. Quantum considerations almost certainly preclude the extraction of a sufficiently detailed description, and such a discontinuous process would not preserve personal identity. The only possible way would be a gradual and continuous disassembly and reassembly with an ongoing causal link between the two separated halves.

Uploading. Like teleportation, transferal of a human mind from a brain to an artifact is almost certainly impossible and would nevertheless not preserve personal identity. Were either technology possible, then a minor improvement would be a non-destructive version that preserves the original body and brain, thus revealing the technology to be a duplicator rather than a teleporter or uploader. The possible technology closest to uploading would be a (relatively) gradual and continuous transformation of the functioning human brain into another substrate.

Energy and Momentum Non-Conservation. There will never be a way to increase the available energy or change the net momentum in a closed system.

5.7.2. Social Science / Futurology / Improbable Advances

Designer Contact. In his novel Contact, Carl Sagan suggested that the universe could have been designed and that its designer could have encoded a message in a transcendental number such as pi or e. Such a situation does not seem logically impossible, in that it would not be on its face a logical contradiction if for example the Bible turned out to be so encoded. The existence of any such message would in fact have to be considered a logical necessity. If so, it could not be considered an act of designer volition, unless one granted degrees of freedom in the design of mathematical logic itself. Such freedom seems incompatible with the very notion of logic: rules of inference that are binding in all possible worlds.

Super-Intelligence. Cognitive ability can increase quantitatively in efficiency, flexibility, speed, capacity, bandwidth, and network associativity, but not qualitatively in its kind of

reasoning or knowing. There are no forms of reasoning or kinds of knowledge that are in principle inaccessible to regular intelligence.

Human Evolution. Humanity is very unlikely to undergo significant further natural evolution. Since the beginning of the Neolithic Age, the development of humanity has been influenced much more by changes in culture than changes in genes. This will continue indefinitely, even considering genetic engineering.

Singularity. The **Singularity** is what Vernor Vinge describes as a moment in the future when the ongoing exponential increases in technological capability culminate in a discontinuity beyond which predictions based on continuous extrapolations do not apply. One candidate for the Singularity is when humanity improves artificial intelligence to the point that it is better than humans at improving artificial intelligence. Another candidate is when the world's computers are networked into a single self-conscious mind. A third is when runaway productivity is achieved through artifactual life or nanotechnology, perhaps provided by extraterrestrial intelligence.

The Singularity will not happen. First, the limits to intelligence apply to artificial intelligence as much as to natural. Second, intelligence is likely not to vary qualitatively as a function of things like processing speed or memory that are increasing exponentially. Third, the effort to make minds faster or smarter will quite likely be subject to diminishing returns. Fourth, artificial minds will at first not be designed but rather grown and evolved, and will be subject to most of the same limits as minds that are naturally grown and evolved.

Antigravity. There will never be a way to repel matter by virtue of its mass, or even to just shield the attractive gravitational force of mass. Nor will there be an inertial drive -- a way to accelerate an object uniformly, as in a gravitational field.

Vacuum or Zero-Point Energy. It is unlikely that humans will ever be able to extract useful amounts of energy from the vacuum or zero point.

5.7.3. Social Science / Futurology / Academic Developments

Academic Developments: the trends and changes in what humans know.

Philosophy

Loss of faith. By explaining the overwhelming majority of apparent Design in the universe, Darwin's theory of evolution made faith in a "God of the gaps" essentially indefensible among intellectuals. As modern physics eliminates the last traces of apparent Design in the universe, intellectual fideists have in the 20th century retreated from actual revelation-based faith. They are seeking refuge in either outright mysticism or a false skepticism that pretends deism is a skeptical epistemology instead of a supernaturalist metaphysics. Rank-and-file fideists are responding variously with fundamentalism, mysticism, and (primarily) an operational agnosticism that maintains only the trappings of faith. This hollow fideism will dilute into vague agnostic mysticism by about 2150, while hardcore fideists will dwindle and become increasingly isolated.

Decline of mysticism. While faith will continue to dwindle sharply, mysticism will continue to absorb an infusion of former fideists as they confront Darwinism and are exposed to Eastern

mystical traditions. Mysticism will thereafter decline asymptotically to a core minority devoted to altered mental states and ecological primitivism.

Spread of skepticism. The revolutions in biology and physics from 1859 to 1929, and the subsequent technological improvements in telecommunications and productivity, will continue to fuel the spread of humanist skepticism. In developed societies like America, belief in revelation will dwindle as rapidly as did (for example) belief in the subhmanity of Negroids. The decline of revelation-based faith will be somewhat disguised by its transformation into a bland mystical reverence for the alleged intention of revelation, but the loss of dogmatic faith will be apparent to those who bother noticing it. Key indicators will be the decreasing number of humans who believe that their mind -- including memories, consciousness, and personality -- will survive death, or who have serious beliefs in the paranormal.

Consolidation of philosophy. Continental philosophy will continue to thrive for at least a century, especially among humans who misunderstand or fear the recent progress in science, technology, and sociopolitics (viz., the ascendancy of free-market capitalism). Positivism will be the tacit or explicit belief of those leading this ongoing progress. Positivist epistemology and extropian ethics will in the Third Millennium displace first Continental philosophy and eventually most competing forms of mysticism and faith. This will complete the move toward skeptical empiricism that began in the Renaissance. Most fundamental philosophical issues will thenceforth be considered settled, similar to how Realism and Substance Dualism are no longer serious philosophical positions. These developments have some chance of being altered by two technological advances: artificial intelligence, and communication with extraterrestrial intelligence. While extropian ethics is unlikely to be affected, either advance could offer compelling contributions to epistemology or even metaphysics. The most likely contributions would be toward clarification and formalization, and not towards radically alternative philosophical positions.

Mathematics

There is little prospect of fundamental advances in mathematics similar to those that happened during the Machine Age. Future progress in mathematics will consist primarily in formalization and in proofs such as:

- Non-existence of a polynomial-time solution for NP-complete problems
- Continuum Hypothesis

Physical Science

Fate of the universe. In the first few decades after 2000, humans will learn the fate of the universe: collapse, infinite expansion, or asymptotic expansion. Observations in 2000 indicate infinite expansion, but theoretical elegance argues for asymptotic expansion.

Origin of the universe. In the first few decades after 2000, humans will create a quantum theory of gravity that will unify it with the other physical forces. By roughly 2100, humans will learn almost all they will ever know about how the laws of physics are constrained to be the way they are, how they allowed for the Big Bang to happen, and how many physical free variables there are.

Biology

Genomics. Molecular biologists will continue for many centuries to sequence the genomes of entire species and the genotypes of individual humans. This will allow an inexorably

increasing understanding of the evolutionary ancestry of earth's taxa, and of the genealogy of earth's humans. Genomics and electronic genealogy will combine to create a worldwide genealogical network that will include almost all humans born in literate societies after 1900 or even earlier.

Genesis. By about 2050, molecular biologists will be able to describe in increasing detail how life based on ribonucleic and amino acids arose on Earth four billion years ago as a result of auto-catalytic chemical processes of increasing complexity. Biologists will also be able to estimate how probable or improbable the development of life was.

Paleontology. Over the first century or two after 2000, biologists will greatly increase human understanding of how and why life evolved as it did over the last few billion years. In particular, anthropology will reach a general but not detailed understanding of how and why intelligence developed in hominids.

Exobiology. It is likely that by about 2100, humans will discover

- tangible evidence of (probably extinct) native life elsewhere in the solar system;
- spectrographic evidence of life outside the solar system;
- electromagnetic evidence of intelligence outside the solar system; or
- technological artifacts deposited in the solar system by extra-solar intelligence.

The latter two discoveries seem more likely. Any one of them will accelerate the decline of faith and reinforce skepticism as a more attractive alternative than mysticism. If humans discover life but not intelligence, it will emphasize the responsibility of humanity to preserve and promote life. If humans discover neither life nor intelligence, it will emphasize the uniqueness and preciousness of the earth's ecosystem and the intelligence it has produced.

Biochemistry. Humans will in the 2000's slowly reverse-engineer the genomes of H. sapiens and other important terrestrial species, allowing increasingly radical genetic engineering.

Neuropsychology. Humans will in the 2000's gradually unravel the details of how the neural processes of the human brain create mental phenomena like consciousness, cognition, perception, affect, and volition.

Social Science

Economics. Economic theory and practice will be refined as information technology allows the ever-improving collection and processing of economic data. However, information technology and central planning are unlikely to ever run humanity's economy as efficiently as the distributed processes of a free-market economy.

Sociology and Political Science. Humans will grow increasingly convinced that libertarian capitalism under federal republican democracy is the sociopolitical system that best provides for human justice and prosperity.

Psychology. Cognitivism will continue to be the most successful school of psychology, and Freudianism will be more and more widely discredited. Human efforts to communicate with cetaceans and with other primates will be tightly constrained by the limited cognitive and linguistic ability of these animals.

Linguistics. Aided in part by human genomics, linguists will make some more progress in

tracing the family tree of human languages, but will never know many details about how the first human languages arose and what they were like.

History. Fluctuations of theme and emphasis in the interpretation of history will continue but will ultimately dampen out. There will not be a theory of history that can reliably predict the future or deterministically explain the past.

5.7.4. Social Science / Futurology / Technological Developments

Technological Developments: the trends and changes in what humans know how to use.

Space

Exploration. Humans will continue robotic exploration of the solar system, including sample return missions by 2020. Humans will establish by 2100 an unmanned radio observatory on the far side of the moon, which is the most radio-quiet place in the solar system. Humans will by 2200 launch robotic telescopes to use the Sun's gravitational lensing out at the edge of the solar system. Humans will by 2300 start sending primitive Von Neumann probes to explore the galaxy and radio their findings back to earth. By about 3000 humans will begin receiving telemetry from high-speed flybys of nearby star systems.

Stations. Humans will by 2200 establish permanent manned stations in Earth orbit and perhaps on the moon, primarily for microgravity and spacecraft manufacturing. Extraterrestrial mining and mass production for terrestrial use is unlikely ever to be competitive with terrestrial processes. Extraterrestrial energy collection or generation is likely not to be competitive with terrestrial processes until well after Earth has too much heat pollution to be able to use the extra energy.

Colonization. There are several reasons humans will want to establish ecologically self-sufficient colonies beyond Earth:

- To enjoy sociopolitical independence or isolation;
- To relieve terrestrial population pressure; or
- To preserve the species in a "lifeboat".

Humans will by about 3000 create self-sustaining extraplanetary colonies, first on the moon and Mars and later in space habitats. By 4000 the long-time citizens of a mobile space habitat may be willing to embark on the long journey that would bring their descendants to a nearby star system.

If attempted at all, the terraforming of Mars, Venus, or a moon of Jupiter or Saturn would likely not begin for several thousand years and might take thousands of years more to complete.

Quanta

Photonics, optics, and computational processing of spread-spectrum radio will lead to an enormous increase in bandwidth by 2020.

Molecules

Nanotechnologyis the creation and use of materials and devices constructed by arranging individual atoms and molecules. Nanotechnology will be used to create extraordinarily strong or light materials and extraordinarily tiny and versatile machines. Self-reproducing nanotech "assemblers" may not be feasible for several centuries, and will not be as versatile as some

would hope. The lesson of software is that even when manufacturing costs fall to zero, design and development usually remains a unique problem for each application of the technology.

Life

Genetic Engineering. Humans will over the next few centuries use genetic engineering to change natural organisms into increasingly useful forms. However, it will require centuries more before humans fully understand the biochemistry of even the simplest natural living system. After a millennium or so, humans will be able to design new ribonucleic organisms. After perhaps another millennium, humans will be able to design organisms with non-ribonucleic biochemistry.

Artifactual Life is life created by intelligence and not based on natural life. Humans will in about two centuries be able to create artificial systems that can reproduce themselves. After another century or so, humans will be able to create Von Neumann probes. A **Von Neumann probe** is a device designed to travel to another star system and reproduce itself there.

Information

Computing. After 2050 the primary constraints on human computing technology will not be processing speed or communications bandwidth or memory capacity and density, but rather physical limits of

- heat dissipation;
- energy density of batteries;
- communications latency;

and human limits of

- sensory and cognitive I/O bandwidth;
- user understanding of software complexity;
- designer understanding of software complexity; and
- ability to specify complex requirements unambiguously.

Display technology will plateau around 2030 with a combination of affordable flat displays and wearable retinal direct-projection systems. Neither quantum nor biochemical computing will prove expedient.

Brain

Neuropsychology will allow the creation of neural interfaces and prosthetics for sensing, computing and communicating. However, mind-reading technology will not improve much beyond current polygraphs, except perhaps through invasive nanotechnology that would probably require extensive adaptation to individual brains.

Mind

Artificial Intelligence is intelligence created by intelligence and not based on natural intelligence. Humans will develop AI in about two hundred years. However, these systems will initially not be designed or engineered but rather grown or raised, much as natural human intelligences are. Another millennium may be required before humans understand the inner workings of intelligence enough to modify or augment it.

Automentation. Will humans find a way to transform their natural brains into artificial ones that are easier to maintain and augment? Such techniques might depend on molecular biology and neuropsychology as much as on nanotechnology and information processing.

Exopsychology. When (and if) humans detect extraterrestrial intelligence (ETI), several possibilities for communication will exist.

1-way transmission. If ETI is detected through electromagnetic emissions over interstellar distances that are not intended to communicate with emerging civilizations such as earth's, then humanity will have to introduce itself. The important issues will be what to tell and what to ask. Humanity should tell ETI a summary of its knowledge of itself and the universe, perhaps by sending information similar to that in this text. (The summary would have to be made intelligible to ETI, perhaps by including a multimedia dictionary and grammar of the relevant human language.) Humanity should ask ETI for a summary of the ETI's knowledge, including available answers for humanity's major unanswered questions and technological assistance in areas like communication, information processing, energy, transportation, and materials.

1-way reception. If ETI is detected through electromagnetic signals over interstellar distances that are intended to communicate with emerging civilizations, then there is a wide range of possible messages the signals could encode. ETI might be broadcasting merely its existence, telling nothing more than the sort of rudimentary information that humanity included in its own 1974 Arecibo transmission. Another extreme possibility is that a federation of ETIs might be broadcasting a continuously-updated "Encyclopedia Galactica" summarizing all their knowledge. Any such message would be designed to be readily intelligible at least at a superficial level, while advanced and detailed understanding might overtax humanity's current linguistic or technological competence.

2-way communication. The third possibility is for 2-way communication, for which interactive latency is the critical variable. Interstellar communication would have a latency of at least decades or centuries, while communication with an ETI presence inside the solar system would have a latency of at most a few hours. Interstellar 2-way communication would merely be a series of 1-way transmissions and receptions. By contrast, intrastellar communication could permit the exchange of time-critical information or even material goods. ETI could greatly accelerate advances in

- mathematics;
- the physical sciences of physics, astronomy, and chemistry;
- the industries of energy, transportation, materials, manufacturing, computing, and communication; and
- the fields of artifactual life and artificial intelligence.

ETI would likely confirm much human philosophy and economics, expand sociology and political science, and significantly generalize psychology and linguistics. ETI would not be able to advance human history or medicine, or terrestrial biology and biotechnology in general. However, it is conceivable that ETI could give human paleontologists some data or even biological samples acquired from Earth millions of years ago.

5.7.5. Social Science / Futurology / Industrial Developments

Industrial Developments: the trends and changes in how humans carry out their activities.

Food Production

Genetic engineering will continue to improve crop yields and hardiness. By 2050 the price of fresh water will hit a permanent ceiling determined not by its natural supply but by the energy cost of its desalinization and transportation. By about 4000, humans will use genetic engineering to culture animal tissue in bulk instead of raising animals en masse. By about 5000, humans will have geno-industrial techniques for efficiently mass-producing food consisting of only of essential nutrients (glucose, amino acids, vitamins, minerals, and lipids) and made delectable by artificial flavors or direct neurological stimuli. Human population on earth will ultimately be limited not by food production but by heat pollution.

Sheltering

Over the next century or so, cities will be transformed from centers of industry and work to centers of culture and entertainment. Telecommuting will blur the distinction between home and office, and will allow humans to locate their homes by climate, culture, and time zone rather than by proximity to industry. Undersea or aerial dwellings are not likely to ever be built in significant numbers. Floating communities and estates will by 3000 become increasingly popular among humans unable to afford scarce land property in desirable climates or in both hemispheres. Human population on earth will ultimately be limited not by living space but by heat pollution. Only when heat pollution becomes a serious problem on Earth will humans start building significant populations beyond Earth.

Communication

Networking. Packet-switched networks like the Internet and its successors will be the primary technology humans use for remote and mass communication for at least several thousand years, and perhaps indefinitely. Communication costs will become independent of distance. Bandwidth will be limited only by the deployment of fiber optic lines and wireless local loops. Almost every device with any internal information state or human interface will have (usually wireless) connectivity to the global network. Multi-party telepresence will allow routine arbitrary amounts of social interaction among even distant family and friends. Public-key cryptography will always allow secure and private communication even if network traffic can be intercepted. Networking of ubiquitous stereo and spherically immersive audio-video sensors will combine with satellite and topographic data to allow real-time telepresence at, or virtual travel to, almost any interesting place on Earth. Archival storage of such sensor data will allow a sort of read-only time-travel into the past.

Storage. Storage and recording technologies will increase in capacity, speed, and affordability, such that the major cost associated with storage will be the intelligent effort required to organize or digest it. Humans will by 2100 be able to digitally record, archive, and transcribe as much as they want of what they see, hear, and say over their entire lifetimes. An ever-increasing majority of existing text, audio, video, and images will be digitally archived into what will be in effect a library of humanity searchable from anywhere on the global network. Existing automated translation technology will make archived texts available in any major human language. Real-time voice recognition will by 2010 be combined with automatic translation and speech generation to produce a crude but effective "universal translator" that will allow a monolingual human to converse (at least slowly and simply) with any speaker of any major human language.

Entertainment

Media. The digitization of music will be followed by the digitization of television, movies, books, and periodicals by 2020. This trend will lead to the routine unauthorized reproduction and distribution of copyrighted text, images, audio, and video. Executable and perishable data are the only data types exempt from this problem: software can decline to function if not licensed, and live data can be hard to reproduce and distribute quickly enough. (Databases can also be exempt, if their owners do not release entire copies and can prevent exhaustive enumeration of the entries.) Only extreme state action could minimize such unauthorized copying, by banning certain copying technologies.

Pre-recorded television programming will by 2030 no longer be mainly viewed on broadcast channels carrying occasional commercials. Such viewing will first move to time-shifted commercial-skipping recording and then to on-demand downloading financed by integrated banner and product placement advertising as well as by voluntary micropayment tips. Even live programming (e.g. sports and news) will have difficulty making viewers sit through commercial breaks. Photorealistic computer-generated imagery will by 2020 replace physical actors, sets, and locations for many video applications, but actors will still be used as input models.

Recreation. Tourism will expand to eventually include currently inaccessible places like the North and South Poles, the summit of Everest, seabottom shipwrecks, and even Tranquility Base on the moon. Virtual visual and auditory reality will by 2020 be the preferred way to play computer games. Humans will continue to play and spectate at sports, while outdoor and wilderness recreation will increase in popularity. Dogs and cats will continue to be humans' favorite pets, but by 2300 they will be genetically improved (e.g. not to shed) and will have competition from pseudo-intelligent robotic "stuffed animals".

Vice. Electronic gambling and pornography will become available to any adult who wants them, and adult access to prostitution will continue to expand. Most psychotropics will be legalized by 2150, especially as neurochemistry becomes more able to manage the problems of addiction and withdrawal.

Transportation

Transportation technology is mainly a function of the cost, size, and weight of energy storage and conversion technology. As artifacts become smaller and lighter and as humans become wealthier and more geographically dispersed, transportation will increasingly become focused on moving humans and the water they need.

Neighborhood. For distances of up to about ten kilometers, humans will increasingly be using battery-powered conveyances such as ultracompact cars, bicycles, and scootboards. Human bodily flight will by 2040 have overcome problems of safety and energy cost, but nuisance due to noise and wash will limit its use in urban areas. Nanotechnology could in theory allow for lighter-than-air bodily flight if it could just construct a lightweight vacuum sphere 5 meters in diameter.

Regional. For distances of up to several hundred kilometers, humans will continue to use cars and their successors indefinitely. In densely populated areas, conventional buses and trains will maintain their popularity, until the autodrive revolution in around 2060. Automated vehicular and traffic control will merge the best properties of road and rail, creating a unified system of roads with rail-like traffic flows. By 2080 VTOL aircraft will be sufficiently cheap, safe, and easy to control that they will be as widely owned as recreational vehicles are in

2000. However, nuisance issues will restrict where they can land and takeoff, and safety will require that they fly under at least semi-automated traffic control in busy flight corridors.

Continental. Air travel will continue to get cheaper and more efficient in the first decades after 2000. By 2030 humans will apply supersonic and perhaps hypersonic travel to a few more commercial intercontinental routes. Air traffic congestion around busy metropolitan areas will be partly abated by automated traffic control but may ultimately require shifting some of the passenger load to long-range high-speed subsonic trains. Ships will continue to handle bulk transport without major changes such as heavy use of of hydrofoils or hovercraft.

Space. Space propulsion will eventually transition from chemical and ion to fusion and eventually antimatter.

Energy

Sources. Fossil fuels will continue to provide the bulk of humanity's power through at least 2150. Solar energy will continue to provide humanity's food (through photosynthesis) as well as a limited part of its power (through water and small amounts of wind, wave, and photovoltaics). Geothermal and fission energy will not supply major parts of humanity's power, but by 2150 thermonuclear fusion will.

Applications. Plugged devices will continue indefinitely to be powered by electricity delivered as alternating current over a power grid that may eventually start taking advantage of superconductivity. Unplugged devices will continue to be powered by chemical batteries that will be the limiting technology for more and more applications. Heating devices will continue to be powered by a combination of fossil fuels and electricity. Internal combustion in vehicles will be supplemented by batteries and flywheels before being replaced by hydrogen fuel cells around 2075. Energy storage through anti-matter containment will by 2300 be feasible for space propulsion and military explosives. Safe and efficient anti-matter batteries would be as revolutionary as chemical batteries have been, but may not be practical before 2500.

Government

Communication technology and free market practice will continue to make government more open and more subject to competitive pressure. Electoral procedures will be modernized towards preference ballots, in which voters rank candidates and in successive rounds of ballot-counting the weakest candidate's votes are redistributed until a candidate achieves a majority. Government will increasingly use market-based mechanisms such as vouchers, negative taxes, or outright privitization. Communications technology will promote less corrupt and more open practices in both politics and government.

Military

Strategic warfare. Ballistic and cruise missiles will continue to be easier and cheaper to attack with than to defend against. Thus nuclear missiles will continue indefinitely to be humanity's premier technology for strategic warfare. (Other technologies of mass destruction are more suited to unconventional warfare.) Nuclear weaponry may ultimately be replaced by antimatter warheads only if antimatter generation and containment technology becomes effective.

Conventional warfare. Fear of nuclear warfare will continue to make conventional warfare an important capability. As it has since Pearl Harbor, conventional warfare will continue to be dominated by the ability of air power to find and strike surface targets (and also to move and supply ground forces). For reasons of miniaturization, agility, and pilot risk, combat aircraft will by 2060 tend to be remotely piloted (unless transmission of aircraft sensor data makes those

aircraft much easier to target). Against opponents without competitive submarine power, sea warfare will continue to be dominated by aircraft carriers. Unless boutique anti-submarine and anti-missile technology can stay ahead of budget submarine and missile technology, aircraft carriers will by 2100 be replaced by submarines carrying aerial weapons systems. Land warfare will continue to be dominated by sensor and guidance technology, especially as all battlefield sensing and intelligence becomes integrated and distributed. Although camouflage, first sight, and first shot will increase in tactical importance, the hard-to-hide and easy-to-hit main battle tank will nevertheless enjoy at least several more decades of battlefield preeminence, thanks to its superior mobility and fire control. Orbital platforms will become increasingly important for communications and surveillance, even as they become more vulnerable to anti-satellite weaponry. This vulnerability will be offset somewhat by the stealthiness and redundancy enabled by miniaturization and lower launching costs.

Unconventional warfare. Fortunately, guerrilla and terrorist warfare will diminish as more and more of humanity enjoys liberty and prosperity. Unfortunately, the weapons available to terrorists will become more and more destructive. Terrorists will increasingly make use of chemical weapons, and will also attempt to create man-made catastrophes. Except possibly for denial-of-service attacks, "information warfare" will by 2020 be useful only against primitive systems that haven't yet taken advantage of modern security techniques.

Ultimate warfare. At the limit, military technology will plateau at two abilities: to gather and use information about enemy plans and actions, and to collect and deploy energy used to disrupt and destroy the enemy's war-making capability. By 2300 humanity will have mastered the fundamentals of nanotechnology and energy storage using anti-matter. At that time, even the most advanced alien aggressor might not really have a qualitative advantage in fundamental technology, but rather a (potentially overwhelming) quantitative advantage in its ability to deploy sensors, warheads, and nanobots. "Information warfare" will not be a significant weapon between separate and hostile civilizations, as information is too easy to secure when there is zero desire for communication and cooperation.

Education

Teaching. Communication and information technology will supplement human teachers and make them more productive, but they will remain essential for educating children. Technology, the shortening workweek, and public policy innovation will make home schooling more common. As information resources grow in richness and as technology makes careers more dynamic, undergraduate education will increasingly focus on learning to learn. Undergraduate and continuing education will be transformed significantly by technology, but graduate research will continue to be like apprenticeship.

Knowing. Technology change and information growth will make meta-knowledge increasingly important: knowing what to know, knowing what one does and does not know, knowing what one can and cannot know, knowing how to find and evaluate knowledge, and knowing how to express, store, and classify knowledge. Meta-knowledge will allow humans to take increasing advantage of information and communication devices and prostheses. However, direct downloading of knowledge will remain almost impossible without a detailed and thorough understanding of mental architecture that is likely to differ subtly but significantly from person to person.

Health Care

Delivery. Telemedicine will become more common, but health care delivery will continue to be provided mainly by physicians working in clinics and hospitals.

Diseases. The incidence of genetic diseases will slowly but steadily be minimized in the next few centuries by genetic screening and engineering. Treatments for the major infectious, immunological and cancerous diseases will be developed through several more centuries of continued research. Curing the major neurological and aging-related diseases will take much of the coming millennium. Obesity and other nutritional diseases will be cured in the next two centuries by advances in pharmacology and in artificial foods. More and more forms of injury will be made non-lethal through surgery and repairable through transplants and prosthetics.

Longevity. Humans will increase their longevity by finding ways to preserve the body, the brain, and the mind. Expected and maximum human longevity will increase by at least thirty years by 2100. Will humans find a way to keep the body or at least the brain alive indefinitely?

Manufacturing

Robotics will continuously increase in importance in manufacturing. Automation will make hardware design and manufacturing increasingly like software design and manufacturing. That is, absolute manufacturing costs will continuously drop, but design and development will remain relatively costly even while becoming absolutely more productive. Ultimately, the cost of material goods will be the amortized cost of specifying and designing them plus only the marginal energy required to manufacture and deliver them.

Merchandising

Disintermediation is the removal of intermediaries (such as retailers, sales agents, and brokers) from transactions between suppliers and consumers armed with information to which formerly only the intermediary had access. Disintermediation driven by information and communication technology will continue to make transactions cheaper and markets more efficient and pricing more competitive. Intermediaries will continue to disappear in markets where they enjoyed quasi-exclusive access to information (initially travel, auto retail) or where they retail fungible items that can be well-described through telepresence (initially books, music, electronics). Fixed pricing will increasingly give way to auctions and reverse auctions. Suppliers will continue to cut design and inventory costs by allowing consumers to directly specify what they want produced by the suppliers' automated plants.

Brokering

Disintermediation will continue to revolutionize or obsolete conventional practice in most brokerage markets. However, the markets themselves for money, equity, commodities, risk (insurance), and space (real estate) will operate indefinitely, joined by markets for natural-resource consumption and pollution.

Services

Most service occupations that can be automated without artificial intelligence or mobile robotics have already been automated. Exceptions are some service occupations in industries like transportation and media, which will be automated in the coming decades using sophisticated (but not truly intelligent) information processing technology.

5.7.6. Social Science / Futurology / Sociopolitical Developments

Sociopolitical Developments: the trends and changes in how humans behave.

Economic Developments

Human standards of living will continue to rise indefinitely because human productivity will continue to rise indefinitely. Productivity is a function of per-worker physical capital (investment), per-worker human capital (education), and capital efficiency (innovation). By 2300 most of humanity will approach the per-worker levels of education and physical capital of the original industrialized nations. Capital efficiency will continue to rise due to technological and industrial developments. The ultimate limit to terrestrial productivity and living standards will be heat pollution.

Economic globalization will continue as the developing world industrializes. By 2100 most of humanity will be using a common currency descended from the American dollar. Inflation will continue to be held to frictional levels of 1% to 3%, while real interest rates will remain indefinitely around 3%.

The workweek will continue to shorten until around 2300 when it reaches about 20 hours, where it will plateau due to psychological factors similar to those that fix humans' daily transportation budget between 1 to 3 hours. Retirement age will continue to decrease on average while retirement itself becomes less clearly delineated. Careers will fade gradually into lengthy semi-retirements that include sabbaticals, avocational employment, and portfolio management. The share of personal income derived from investments will rise compared to that derived from wages. Increases in wealth and automation will minimize the need for labor but never eliminate the need for work. Rather, work will increasingly consist of analyzing and deciding what is to be made or done and how machines can make or do it.

How will the savings and discount rates be affected by increasing longevity? Why are the returns to capital less than its estimated 30% share of all production?

Political Developments

Since the Renaissance the natural trend toward political and economic liberty has been resisted by three kinds of forces:

- tyranny, whether monarchic, autocratic, plutocratic, or ethnic;
- economic securitarianism, manifested as socialism and communism; and
- moral securitarianism, driven by fideist religion.

The era of liberation that erupted in 1989 will by 2040 have eliminated almost all overt tyranny. The major exception will be entrenched and sometimes subtle ethnic tyrannies that will linger for decades until asphyxiated by economic development and modernized communications. Socialism and communism having been discredited, economic securitarianism will linger (perhaps indefinitely) only as the sustaining sentiment behind welfare statism. The moral securitarianism motivated by fideist religion will remain the most serious global obstacle to human liberty, and will not fade as a political force until perhaps 2100.

Global government will emerge slowly over the next few hundred years, as global regulatory bodies are set up to handle more and more government functions. Thus global government will emerge not necessarily from the UN and EU but from organizations like ISO and WTO. Only by around 2500 will there be a truly global federal government with sovereign (but limited) legislative, executive, and judicial powers. Any extra-planetary colonies will be federated into the global government no differently than terrestrial political units. Only the

communications latency of interstellar colonization would create the need for sovereignties independent of Earth's.

Private property and relatively free markets will endure indefinitely. Absolute poverty will continue to diminish as per-capita productivity continues to rise. Institutional relative poverty will continue in the absence of social policies to discourage dependency and encourage private accumulation of human and financial capital. Digital reproduction and distribution of copyrighted expressions will become increasingly rampant and could only be deterred through Gestapo-style inspections of digital watermarks. As a result, copyright will by 2040 be redefined to limit only commercial competition with the owner and abuses of attribution. Purchasing of copyrighted expression will be replaced by voluntary micropayments (of money or attention) made directly to copyright owners.

Packet-switched communication technology will affect politics only in limited ways. Voters will have almost unlimited access to information about candidates' positions, but unfortunately will remain too complacent to use that access effectively. There will be calls to let voters use regular electronic referenda to enact or at least veto legislation. Fortunately, it will be recognized that the electorate remains too uninformed and impulsive to allow this dangerous form of mob rule.

Enfranchisement of fetuses will gradually cease to be a hot issue in America because birth control by 2100 will have drastically reduced the incidence of abortion. Future-phobes will continue to oppose every advance in biotechnology, but in the end their opposition will succeed only when an advance threatens health or property and doesn't just offend their moral sensibilities. Human consumption of meat and dairy will not be outlawed in the long term, as animal rights will not be extended beyond freedom from torture and extinction. These animal rights will be recognized in machines when by 2200 they exhibit convincing affect and possess artifactual life. Around the same time, such machines will be recognized as persons if they exhibit artificial intelligence.

Vice. Electronic gambling and pornography will become available to any adult who wants them, and adult access to prostitution will continue to expand. Most psychotropics will be legalized by 2150, especially as neurochemistry becomes more able to manage the problems of addiction and withdrawal. Tobacco and alcohol will remain legal. Firearms licensing will become increasingly strict, but even handguns will remain legal for some people to own.

Sociological Developments

Humans will indefinitely remain pair-bonded and omnivorous. The number of native human languages will continue to decline drastically as smaller societies become linguistically absorbed into larger ones. English will become increasingly widespread, especially as a second language. Its status as the global second language will enable it to become the native language of a majority of humans by 2600, and of 90% of humans by 3000. A parallel process of increasing intermarriage will significantly blur racial and ethnic distinctions.

When by around 2300 the rest of humanity has closed the development gap with the industrialized world, Earth's population will stabilize near 20 billion. Increasing longevity will result in an average age decades older than ever before. Any progress toward indefinite longevity will, as is typical of increases in living standards, probably decrease the birth rate. The long-term population of the Earth will be limited primarily by heat pollution.

Genetic engineering will increasing allow parents to screen and tune the traits of their children. Sale of gametes and surrogacy services will become more widely accepted. Cloning will mainly be used for reasons of sentimentality and reproductive difficulty. Eugenics will never be a mandatory social policy, but widespread voluntary genetic engineering will have a similar effect.

Religion will decline due to the ongoing loss of faith. Christianity will be hollowed out and diluted into a bland mysticism. Islam will follow along the same track but about 150 years behind. Being already more mystical, Hinduism and especially Buddhism will linger as phenomena more ethnocultural than religious, much like Judaism and Shintoism already are.

5.7.7. Social Science / Futurology / Challenges

Environmental Challenges

Global Warming. Accumulation of greenhouse gases is causing a rise in global temperature of a few degrees celsius. This may by 2050 melt enough antarctic ice to raise sea levels by a few feet and cause some coastal flooding. Warming may make weather cycles more extreme but may also make land more useful in the northern expanses of Asia and North America. Projected greenhouse warming is not severe enough to lead to runaway effects like on Venus.

Heat Pollution. Over the next millennium and for the rest of human history, earth's major environmental problem will be warming due not to greenhouse gases but rather to increased waste heat from non-solar energy (initially petrochemical, but then fusion). The problem emerges when a world population in the high tens or low hundreds of billions all enjoy an energy budget equivalent to the industrialized West in 2000. All the waste heat from all the energy uses adds up, and the laws of thermodynamics guarantee that energy use always creates heat exhaust. Heat pollution will have to be managed to prevent a runaway greenhouse effect like on Venus.

Population. The primary long-term environmental problems caused by human population increase will be heat pollution and pressure on habitats and ecosystems. By contrast, the traditional environmental worries of pollution and resource scarcity are subject to increasingly-effective technological and economic solutions. As Earth's population stabilizes, some will worry that decreasing birth rates will lead to declining population. Any actual decreases in population will be minor and temporary, and underpopulation will never be a long-term problem.

Some ignorant humans fear that "inferior" races are outbreeding their own race. Others fear that decreased reproduction among humans with high incomes or IQs will mean that humanity will be overrun by the poor or the stupid. These fearful humans fail to understand that environment and culture are more important than genes, and that human evolution long ago changed from biological to cultural and will soon change to biotechnological.

Resource Scarcity. The scarcity of a resource is measured by the cost of satisfying the need that it satisfies. By this measure, almost all resources have throughout human history been getting less and less scarce. Fossil fuels will remain abundant at least through 2050, and will likely not be very scarce before fusion replaces them as humanity's primary energy source starting around 2150. Arable soil will through conservation remain abundant, and minerals will continue to decrease in scarcity (i.e. cost). Many species of fish and game will become

increasingly less abundant in the wild, but the cost/scarcity of food in general will continue to decline. Demand for fresh water will outpace most of its natural supply, but the cost of fresh water will eventually plateau at and decline with the energy cost of its desalinization and transportation.

Biodiversity. While food will continue becoming less scarce, the wild plants and animals that constitute earth's ecosystem will come under increasing pressure from humanity's increasing population. Loss of forest and wetlands will threaten fragile ecosystems that harbor rare species. The lost information content of extincted species is effectively impossible to replace.

Pollution. Pollution levels in humanity's air, water, and land will continue to decrease as per-capita income increases and as government requires that economic transactions internalize their polluting externalities. Earth's crust has sufficient volume that solid waste disposal will be simply a problem of transportation. Human population will be limited much more by heat pollution much than by solid waste pollution. Property interests will ensure that soil erosion is mitigated. Government will successfully prevent destruction of the ozone layer.

Infectious Disease. Pathogens will continue their natural evolutionary race against humanity's immunological and pharmacological defenses. Further progress against some pathogens may be frustratingly slow, but genetic engineering will by 2300 make most infectious diseases subject to treatment and many subject even to prevention.

Political Challenges

Populism. As industrial capitalism becomes mature and ubiquitous, humanity will continue to face the popular temptation to redistribute unequal wealth and income or at least regulate association between economically unequal parties. Protectionism will be less of a problem, as governing elites increasingly recognize the utility of free markets, and as the world economy becomes increasingly integrated.

Neophobia. Humans who misunderstand the interplay of economics, ecology, and technology will continue for centuries to oppose technological progress and economic development. Opposition to techno-economic development will continue to be motivated by

- a simplistic and mystical reverence for the environment in its present or recent state,
- a misunderstanding of what is and isn't natural, and
- a general fear of what anything new and hard to understand.

Opposition based on religious faith will grow weaker after trying to stifle biomedical advances like genetic engineering and cloning.

Moral Securitarianism.As fideist religions continue to weaken, their remaining adherents will react with increasing fundamentalism. They will agitate for legal prohibitions against victimless behaviors and technologies that they believe have been banned by their non-existent gods. Except for temporary victories, their agitations will ultimately fail.

Ethnic Conflict.Nationalism and freedom will continue to be the dominant political forces at least until global economic convergence occurs by around 2300. Ethnic conflicts will continue to erupt throughout the 21st century, but they will be increasingly mitigated by political, economic, and communications globalization.

Terrorism. Terrorism will decline with the weakening of ethnic repression and fideist religions. Terrorism by neophobes may continue indefinitely. Ambitious terrorists will attempt

to use chemical, biological, cyberactive, and nuclear weapons.

Discrimination. Overt discrimination will abate sharply as societies modernize their communications and converge economically with the industrialized West. America is an example of how much progress can happen in only two generations. The ultimate test for the elimination of discrimination is intermarriage. Intermarriage and the end of discrimination will cause each other, but the process will take most of the third millennium.

Cyberspace. Communications technology will dramatically undermine jurisdictional and repressive aspects of political authority. Certain jurisdictions will for nationalistic, religious, or neophobic reasons attempt to control how cyberspace affects them. These attempts will be disruptive but will ultimately fail. Repression will decline and political institutions will federate and globalize, but the institution of spatially-defined political sovereignty will continue.

Vice. Human temperance will be increasingly and perhaps severely tested by new technologies. Video games will evolve into virtual reality systems that command as much of some humans' time as do sleep and work. VR will allow perverts and psychopaths to commit virtual crimes that are unspeakable, lifelike, and completely victimless. Neurochemistry will allow the use of psychotropics without problems of addiction and withdrawal. Fideists and neophobes will cite these new technologies as evidence that progress is bad.

Forgery. With digital photography, images will be considered increasingly unreliable as evidence in courts. By 2040, sound and video too will be easy enough to forge that their authenticity will be open to question. Digital certificate techniques will be able to ameliorate these problems only in very limited ways.

Privacy. Privacy will be affected by technology in two ways. First, information processing technology will allow businesses to track customer interactions to arbitrary levels of detail. Customers who consider this a problem will seek businesses offering privacy guarantees, or will patronize intermediation services that offer to protect their identity. Public-key cryptography will always allow secure and private communication and e-commerce even if network traffic can be intercepted.

Second and more disturbing, miniaturization of sensor and storage technology will allow anyone to set up hidden audiovideo surveillance of almost any location to which they ever have physical access. By 2050, this will include locations that can be reached by remote-controlled insect-sized flying sensors. Sensors will use storage technology to avoid the need for the radio emissions that in the past made it possible to "sweep" for bugs. Privacy will only be assured in clean rooms that can be inspected and monitored for intrusion.

5.7.8. Social Science / Futurology / Possible Catastrophes

Natural Catastrophes

Earthquake. Earthquakes and floods will through 2300 still occasionally kill tens of thousands of humans in developing societies. Of even greater historical consequence would be a possible massive earthquake in Tokyo, San Francisco, or Los Angeles. Such a quake could cause on the order of a trillion dollars in damage and could trigger a worldwide depression. In the worst case this would set back human progress by perhaps a decade.

Pandemic. How much of humanity could be killed in the future by a naturally-arising pathogen? In the 1500s and 1600s, European epidemics killed perhaps 90% of the aboriginal

Americans. In the 1400s, the plague killed one third of the humans in Europe. The worldwide influenza of 1918 killed 30 million, and AIDS had killed at least half that by 2000. It seems unlikely that a natural pathogen could kill more than a small fraction of humanity, especially given modern sanitation. Evolutionary pressures tend to make pathogens less virulent over time, and newly-arising pathogens rarely seem to extinct their host species even in their initial outbreak. Genetically-engineered pathogens may be different.

Alien Aggression. The arrival of extraterrestrial intelligence on Earth might seem to pose a threat to human civilization. The arrival of Homo sapiens sapiens in Europe heralded the end of Homo sapiens neanderthalensis. The arrival of Home sapiens in Australia and the Americas quickly led to the extinction of most of the native megafauna. Contact with farming civilization has almost invariably led to the decline or assimilation of hunter-gatherer cultures. Contact with industrial civilization has almost invariably caused severe disruption in pre-industrial civilizations.

Fortunately, ETI would be unlikely to colonize Earth. Biochemical differences would surely render Earth life inedible to any ETI that had not yet become machine-based. As modern economic experience shows, raw human labor is too easy to automate to make enslavement worthwhile. Earth has deuterium-rich oceans of water, but even more water is available on Europa, which is also not as deep in the Sun's gravity well. Except for its reactive oxygen atmosphere, Earth's climate is relatively benign and might be an attractive place to establish an ETI population. However, space faring ETI would probably value Earth more for studying than for exploiting. Space faring ETI could just as easily satisfy its resource needs using the uninhabited parts of the solar system. Note that an alien Von Neumann probe could pose a variant of the robot aggression or nanoplague catastrophes.

Interplanetary Impact. The impact on Earth of an asteroid or comet only a few miles across would have devastating blast, tidal wave, incendiary, and smoke effects. In particular, the global pall of smoke raised by such an impact could block enough sunlight to effectively cancel one or two agricultural seasons and starve billions of humans to death. Such a catastrophe would set back human progress by one or two centuries. With five or ten year's warning, humanity could mount a mission to prevent such an impact by adjusting the impacter's orbit. The probability of such an impact is extremely low, only happening every few hundred thousand years. Less probable by far is impact with or orbital disruption by a small black hole that might wander through the Solar system. Impact with a black hole would effectively destroy the surface of the earth and most or all life on it. Disruption of the Earth's orbit could cause a biosphere-destroying runaway greenhouse effect like on Venus. Even a slight increase in the eccentricity of Earth's orbit would cause ecological disruptions that would probably starve billions of humans. Ejection of Earth from the Solar system would in a matter of months freeze to death all terrestrial life (except perhaps ecosystems around volcanic vents at the bottoms of frozen oceans). Humanity will not be safe from such an event until its first self-sustaining extraplanetary colonies are created around 3000.

Supernova. A supernova would have to be within a few tens of light years of Earth for its radiation to endanger creatures living at the bottom of Earth's atmosphere. No stars that close to Earth will go supernova in the next few million years.

Ice Age. When Earth's next ice age arrives in 10,000 years or so, it will grant slight but welcome relief from the problem of heat pollution.

Magnetic Field Reversal. Earth's magnetic field reverses polarity every few hundred thousand years, and is almost non-existent for perhaps a century during the transition. The last reversal was 780 Kya, and the magnetic field's strength decreased 5% during the 20th century. During the next reversal the ozone layer will be unprotected from charged solar particles that could weaken its ability to protect humans from ultraviolet radiation. However, past reversals are not associated with any changes or extinctions in the fossil record, and the next reversal will not likely affect humanity in a catastrophic way.

Man-made Catastrophes

Nuclear Catastrophe. Nuclear power could result in three kinds of catastrophe: radioactive pollution, limited nuclear bombing, and general nuclear war. Accidental or deliberate radioactive pollution could kill tens or hundreds of thousands, but is quite unlikely to happen. Regional nuclear conflict in the Middle East or the Indian subcontinent could kill several million. Nuclear terrorism against Washington D.C. or New York City could kill more than a million and set back human progress by up to a decade. General nuclear war would kill hundreds of millions and could trigger a nuclear winter that might starve hundreds of millions more. While such a worst case would set back human progress by one or two centuries, existing nuclear arsenals could neither extinct humanity nor end human civilization.

Cultural Decline. Some humans fear that vice, crime, and corruption indicate ongoing social decline or impending collapse. Other humans fear that problems of class division, pollution, education, and infrastructure indicate economic decline or impending collapse. These fears are perennial and unfounded. Past examples of the drastic decline or collapse of a culture or civilization have almost always been due to environmental change, or infection or invasion by outside humans. But after the advent of continental steam locomotion in the mid-1800s, no society remains unexposed to the infections of the others. Similarly, all societies have been made part of a single global human civilization which is not subject to invasion by outside humans. Environmental change indeed poses a set of challenges, but they seem to represent constraints on growth rather than seeds of collapse.

Cultural stagnation is another possible (but milder) kind of potential catastrophe. As in Ming China, Middle Ages Europe, or the Soviet Bloc, stagnation can result if a static ideology takes hold and suppresses dissent. Such a development seems unlikely, given the intellectual freedom and communication technology of the modern world. Ideologies with totalitarian potential include fideist religions, communism, and ecological primitivism.

Bioterrorism. Could a pathogen be genetically designed to be virulent enough to extinct humanity? A pathogen would have to be designed to spread easily from person to person, persist in the environment, resist antibiotics and immune responses, and cause almost 100% mortality. Designing for long latency (e.g. months) might be necessary to ensure wide distribution, but no length may be enough to infect every last human.

Robot Aggression. Some humans fear that the combination of robotics and artificial intelligence will in effect create a new dominant species that will not tolerate human control or even resource competition. These fears are misplaced. Artificial intelligence will be developed gradually by about 2200, and will not evolve runaway super-intelligence. Even when AI is integrated with artifactual life by the early 2200s, the time and energy constraints on artifactual persons will render them no more capable of global domination than any particular

variety of humans (i.e. natural persons). Similarly, humanity's first Von Neumann probes will be incapable of overwhelming Earth's defenses even if they tried. To be truly dangerous, VN probes would have to be of a species with both true intelligence and a significant military advantage over humanity. Such a species would be unlikely to engage in alien aggression.

Nanoplague. Self-replicating nanotechnology could in theory become a cancer to the Earth's biosphere, replacing all ribonucleic life with nanotech life. The primary limit on the expansion of such nanotech life would, as for all life, be the availability of usable energy and material. Since any organic material would presumably be usable, the primary limit on how nanocancer could consume organic life would be the availability of usable energy. Fossil fuels are not sufficiently omnipresent, and fusion is not sufficiently portable, so nanocancer would, like ribonucleic microorganisms, have to feed on sunlight or organic tissues. Ribonucleic photosynthesis captures a maximum of about 10% of incident solar energy, while nanocancer should be able to capture at least 50%. The only way to stop nanocancer would be to cut off its access to energy and material or interfere with its mechanisms for using them.

5.7.9. Social Science / Futurology / Timeline

2010	Automatic translators allow monolingual humans to converse with any speaker of any major human language.
2015	Bandwidth has increased enormously due to fiber optics and spread-spectrum radio.
2020	Almost all overt tyranny has been eliminated. Physicists have confirmed that the fate of the universe is asymptotic expansion. Most text, images, audio, and video is produced and consumed digitally. Unauthorized reproduction and distribution of such media is routine. 1st Martian sample return has revealed no conclusive fossil evidence of life.
2030	20% of former fideists have become mystics. Radio astronomers have discovered signals from extraterrestrial intelligence. Computer display technology plateaus with cheap flat panels and retinal projectors.
2040	Physicists have completed a quantum unification theory. Personal bodily flight has become commercialized. Transonic flight still serves just a few intercontinental routes.

2050 Molecular biologists have detailed description of how life on Earth began.
Computing is limited not by processing, storage, or bandwidth but by heat, latency, and batteries.
Fresh water availability is now limited only by energy costs of transportation and desalinization.
Automated vehicle/traffic control gives rail-like traffic flow to roads.
Privacy is curtailed by commercial availability of mobile remote-controlled microsensors.

2075 Physicists have reached limits of knowing why fundamental physical laws are as they are.
Hydrogen fuel cells are replacing internal combustion of fossil fuels.
VTOL aircraft are as widely owned as RVs in 2000.

2100 Expected and maximum human longevity have increased by 30 years.
Humans are able to record and archive all they ever see, hear, and say.
Most of humanity is using a common currency descended from the American dollar.
Unmanned radio observatory has been established on far side of moon.

2150 Remaining fideisms have diluted into agnostic mysticism; true fideists dwindle.
Fusion provides major parts of humanity's power.
Most psychotropic drugs are legal; addiction is prevented neurochemically.

2200 Permanent manned space stations in Earth orbit have been established.
1st artifactual life and artificial intelligence systems have been created and enfranchised.
Obesity and other nutritional diseases are curable.

2300 1st Von Neumann probes have been dispatched from Earth.
Most genetic, infectious, immunological, and cancerous disease is preventable or curable.
Most of humanity enjoys Western standards of living and productivity.
Earth's population has stabilized at around 20 billion.
The workweek has stabilized at around 20 hours.

2400 Extropian positivism has displaced most other belief systems.

2500 Heat pollution has become the last significant environmental problem.
A truly global federal government exists.

2880 Asteroid 1950DA (1km wide) has a 1/300 chance of hitting Earth March 16.

3000	Humans have created on the moon their 1st self-sustaining extraplanetary colony.
	Earth has received 1st telemetry from unmanned probes to nearby stars.
	Neurotechnologists have started to modify and augment natural human intelligence.
	Genetic engineers have designed first artificially-created species.
	English is the native language of 90% of humans.
	Floating communities and estates have become increasingly popular.
4000	1st embarkation of mobile space habitat toward nearby star.
	Humans culture animal tissue in bulk rather than raise animals en masse.
	As the next ice age begins, Earth is about 0.5C cooler (relative to 2000CE) than it otherwise would have been.
10K	1st terraforming(of Mars or a Jovian moon) has started to show progress. Another 90Kyr-long ice age has begun, and Earth is about 3C cooler (relative to 2000CE) than it otherwise would have been.
16K	The precession of Earth's axis has made Vega the northern pole star.
23K	The 1679-bit 1974 Arecibo interstellar message finally covers the 21Kly distance to its target, the globular cluster M13 (300K stars).
100K	A majority of persons descended from H. sapiens lives beyond Earth.
	An object more than a kilometer wide will probably have struck Earth.
250K	Earth's magnetic will by now probably have reversed, as it does every few hundred thousand years and as it last did 780Kya.
1M	A majority of persons descended from H. sapiens lives beyond the Solar system.
	The red dwarf Gliese 710, currently 63ly away, will pass within 0.5 ly of Sol and appear at 0.6 magnitude.
2M	Pioneer 10 (launched in 1972, 68 ly away) passes near Aldebaran at 44 Mm/h.
50M	Africa has collided with Europe (closing the Mediterranean), Australia has merged with SE Asia, and California has slid up the coast to Alaska
100M	Earth has information from probes to the Andromeda galaxy.
226M	Sol has completed one more orbit around the Milky Way's center.
250M	The Americas merge with Afro-Eurasia, reducing the (formerly growing) Atlantic to an inland sea.
1B	Earth has information from probes to every star system in the Milky Way.
2B	Increased Solar output has extincted any remaining Earth life due to runaway greenhouse effect.
6B	Sun ends its main-sequence life as a red giant large enough to engulf and possibly swallow Earth, and then cools into a white dwarf.
	Milky Way and Andromeda galaxies collide.
10B	Milky Way galaxy's intelligent population stabilizes at its maximum.

100B	Living systems are huddled around red dwarfs for light and warmth.
	The charred and frozen Earth-Moon system (if not already swallowed by Sol's red giant phase) has stabilized to a 47-day rotation/revolution at a distance of 560,000 km.
150B	Due to the universe's accelerating expansion, the view of everything outside the gravitationally-bound Local Group of galaxies stops changing and fades away.
10^{14}	Almost all stars stopped shining, having become brown or white dwarfs. Little or no life remains.
10^{15}	Planets have been dislodged from their solar systems by stellar close encounters.
10^{20}	The remaining stars (brown or white dwarfs) have all either been dislodged from their galaxies, or collapsed into central galactic black holes. Dwarf collisions cease, and the last few stars formed thereby stop shining.
10^{40}	Proton decay has left the universe with only black holes and subatomic particles.
10^{100}	The last black hole evaporates, emitting the cold dark universe's final flash of visible light.

6. Epilogue

In a universe condemned to inexorably increasing entropy, we value extropy. As autonomous living intellects, we persons value intelligence and life and the autonomy they need to flourish.

Make your moments joyful and your memories fond.

A. Appendices

1. **Unanswered Questions**.
2. **References**.

A.1. Appendices / Unanswered Questions

- Philosophy
  - Metaphysics
    - Why is there something rather than nothing? Is there an objective purpose for that which exists? How could one recognize an answer to these questions? Are these questions meaningless?
    - Is causality an illusion? Does every effect have a cause, or do some effects have no cause? Can there be a cycle of causality, in which an effect both precedes and contributes to its cause? Can one know the answers to these questions?
    - Do space and time have absolute existence independent of their contents? Or are they simply a system of relations among entities and events? Is there a way to answer these questions, or would any answer not make a difference?
  - Epistemology
    - Might the world be an illusion or dream?

        - Do minds have strong free will, or can their decisions in principle be inferred from sufficient knowledge of prior circumstances?
        - Is affect indeed an inevitable property of any volitional system with complex motives?
    - Axiology
        - Can there be an objective rational basis for values?
        - What would an omnipotent omniscience value?
        - Should every competent adult human be free to indulge in vice to his own detriment, or are some vices so self-detrimental that the state should regulate them?
        - Would persons with highly developed senses other than sight and hearing ever consider these other sensations to be beautiful and thus an artistic medium?
        - How different would be the aesthetic preferences of humans and non-human persons with similar faculties?
- Natural Science
    - Physics
        - Electromagnetics
            - What causes high-temperature superconductivity?
        - Relativity
            - Why are inertial mass and gravitational mass identical?
            - Is time travel physically possible, perhaps only if paradoxes are censored?
            - Why is the vacuum energy so small?
        - Quantum Theory
            - Are quarks and electrons truly point-like and dimensionless?
            - How can Quantum Theory and Relativity be reconciled?
            - Is Quantum Theory correct in requiring either anti-relativistic faster-than-light influence or time-reversed causality?
            - How do black holes destroy information (other than that of mass, charge, angular momentum, and temperature) that Quantum Theory says must be preserved?
        - Cosmology
            - Why did the Big Bang happen?
            - What is the fate of the universe: open, closed, or asymptotically flat?
            - Why does the universe's expansion appear to be accelerating?
            - How can we explain the existence and values of the free variables?
            - Does the information destroyed in black holes constitute an arrow of time?
            - What is the Dark Matter that seems to be needed to account for the gravitational mass of galaxies?
            - Why does there seem to be more matter than antimatter?
    - Astronomy
        - What causes gamma ray bursters?
        - Why are there fewer solar neutrinos than predicted?

    - Biology
        - How did life arise?
        - Is there life and intelligence beyond earth?
        - How improbable was the genesis of life on an earth?
        - How improbable was the evolution of intelligence on earth?
        - How improbable was the evolution of humans on earth?
        - How did sex evolve?
        - How did flight evolve?
        - Anthropology
            - How did language evolve?
            - Why are there more right-handers than left-handers?
            - Why do males have nipples?
            - Why do humans make and enjoy music and humor?
- Social Science
    - Linguistics
        - Did all languages descend from a common ancestor?
        - Do animals have languages?
    - History
        - What caused the fall of the Mayan Empire?
    - Futurology
        - Will humans find a way to keep the body or at least the brain alive indefinitely?

A.2. Appendices / References

1. **General References**.
2. **Philosophy References**.
3. **Mathematics References**.
4. **Natural Science References**.
5. **Social Science References**.

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