



Integrity and Values in Science

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Preamble

- **“That is the idea that we all hope you have learned in studying science in school—we never explicitly say what this *is*, but just hope that you catch on by all the examples of scientific investigation.”** Richard Feynman.
- **“At times I even persuade myself that I can glimpse some of the answers, but this is a common delusion experienced by anyone who dwells too long on a single problem.”** Francis Crick.
- **“The secret to real happiness is low expectations.”** Barry Schwartz.



Science as an Emergent Property

“... the conditions for the success of science are the values of man which science would have had to invent afresh if man had not otherwise known them ...” J. Bronowski.

- **Honesty**
- **Tolerance**
- **Self–respect**
- **Independence**
- **Imagination**



Post-Truth – Skepticism & Denial

- **“Nothing is so difficult as not deceiving oneself.” Ludwig Wittgenstein.**
- **"Thinking is to humans as swimming is to cats; they can do it but they'd prefer not to." Daniel Kahneman.**
- **"Intellectual rigor annoys people because it interferes with the pleasure they derive from allowing their wishes to be the fathers of their thoughts." George Will.**

Post-Truth – Personal Belief Trumps Facts

- **“... the false notion that democracy means that my ignorance is just as good as your knowledge.”** Issac Asimov.
- **"... it is so much easier, mentally and emotionally, to take one side and hold to it tenaciously than to admit complexity and ambiguity; to start by believing, and fit evidence into that belief, rather than start by disbelieving, and seek the best evidence that confirms and disconfirms that belief."** Carol Tavris.
- **“Humans are irrational. Is that statement rational? If it is, it cannot be true ...”** Stephen Pinker.

Post-Truth – Cognitive Biases

- **Confirmation bias** – fitting evidence to theory rather than the theory to the evidence.
- **Anchoring/framing bias** – over-relying on initial information as baseline for comparison.
- **Availability/Recency bias** – most immediate, memorable, or emotional anecdote.
- **Choice supportive bias** – post-purchase rationalization.
- **Jerk factor** – valuing bravado over contemplative .
- **Ostrich effect** – avoiding anything contrary.

Post-Truth – Logical Fallacies

- **"But ignorance of reasons would prove the absence of causes only for an omniscient being."** Leslie Kish.
- **Pluralistic Ignorance** – members of a group don't believe something, but think others do.
- **Circular reasoning** – using X to prove Y and Y to prove X.
- **False dichotomy** – reducing an issue to a binary choice.
- **Appeal to Consequence** – premise must be true based on its expected result.
- **Appeals to repetition, popularity, possibility, authority, or tradition.**

Post-Truth – Death of Expertise

- **When people become attached to a theory, they fit the evidence to the theory rather than the theory to the evidence. Michael Lewis.**
- **"My father loved football but disliked footballers. You have to keep people who do things apart from what they do." Sargent Lewis on Inspector Morse.**
- **"Thus, at least some of the people who reject expertise are not really, as they often claim, showing their independence of thought. They are instead rejecting anything that might stir a gnawing insecurity that their own opinion might not be worth all that much." Tom Nichols.**

Post-Truth – Uncertainty

- **“Science is what you know, philosophy is what you don’t know.”** Bertrand Russell.
- **“There are *known knowns*; there are *known unknowns* ... But there are also *unknown unknowns*, i.e., things we don't *know* we don't *know*.”** Donald Rumsfeld.
- **“Philosophy of science is about as useful to scientists as ornithology is to birds.”** Richard Feynman.
- **“Postmodernist thought is being used to attack the scientific worldview and undermine scientific truths; a disturbing trend that has gone unnoticed by a majority of scientists.”** Marcel Kuntz.

Post-Truth – End of Science

- **"Science, then, is not like the onion in the often used analogy of stripping away layer after layer to get at some core, central, fundamental truth. Rather it's like the magic well: no matter how many buckets of water you remove, there's always another one to be had."** Stuart Firestein.
- **"Art is never finished, only abandoned."** Leonardo da Vinci.
- **"We have been led to imagine all sorts of things infinitely more marvelous than the imaginings of poets and dreamers of the past. It shows that the imagination of nature is far, far greater than the imagination of man."** Richard Feynman.

Post-Truth – Thinking Fast & Slow

- **"My intuitive thinking is just as prone to overconfidence, extreme predictions, and the planning fallacy ... as it was before I made a study of these issues." Daniel Kahneman.**
- **"The very nature of our brains – evolved to guess the most plausible interpretations of the limited evidence available – makes it almost inevitable that, without the discipline of scientific research, we shall often jump to wrong conclusions, especially about rather abstract matters." Francis Crick.**

Post-Truth – Summary

- **"Beware of moments when facts seem to confirm prejudices. Such times are traps, when the well meaning are misled and the mean-spirited gain confidence."** Arthur Tietelbaum.
- **"The smallest dog can pee on the biggest tree."**
Australian bushman, compliments of Barry Snowden.
- **"Those ignorant of the historical development of science are not likely ever to understand fully the nature of science and scientific research."** Hans Krebs.
- **"The siren song of unreason is not just a cultural wrong turn but a dangerous plunge into darkness that threatens our most basic freedoms."** Carl Sagan

Scientific Concepts – Terms

- **Normal Usage**
 - **Fact = highest state of truth or knowledge.**
 - **Law = tendency for behavior in a certain manner.**
 - **Theory = hunch, lowest form of truth.**
- **Scientific Usage – reverses order**
 - **Theory = highest state of knowledge, explains WHY behavior occurs and predicts action over space and time. Unifies disparate observations providing a common explanation.**
 - **Law = may be mathematical, describes behavior and action over a domain.**
 - **Fact = true occurrence, but boring, lacks explanation.**



Scientific Concepts – Observations

- **“We now understand that science is built not on facts but on observations.” J. Bronowski.**
- **"Science is about measurement. There is no maturity of a scientific field until they have come up with a system of measurement." Neil DeGrasse Tyson.**
- **"If you cannot measure it, you cannot improve it." Lord Kelvin.**
- **"Government is keen on amassing statistics – they collect them, add them, ... prepare wonderful diagrams. But what you must never forget is that every one of these figures comes in the first place from the chowty dar (village watchman), who just puts down what he damn pleases." Stamp's Law of Statistics.**



Scientific Concepts – Facts

- **"And if science were a copy of fact, then every theory would be right or wrong, and would be so forever." J. Bronowski.**
- **"... that science is therefore not a mechanical index of facts, but an evolving activity." J. Bronowski.**
- **Mean-seeking mensurationist versus the variance conservationist. Albert R. Stage.**
- **"I have insisted that the scientist does not merely record the facts; but he must conform to the facts." J. Bronowski.**
- **"For no fact in the world is instant, infinitesimal and ultimate." J. Bronowski.**



Scientific Concepts – Theories

- **“You can prove concepts in mathematics, because you can see every logic detail from first axioms. It just takes one exception to change a theory.”** Albert Einstein.
- **“Scientific knowledge is a body of statements of varying degrees of certainty – some most unsure, some nearly sure, but none absolutely certain.”** Richard Feynman.
- **“We are making a unity – a complete (theory) – a unity out of variety.”** J. Bronowski.
- **"Evidence is data that supports one theory and rules out others."** Alex Edmans.
- **“... these are the bold creations of science, the strong invisible skeleton on which it articulates the movements of the world.”** J. Bronowski.



Scientific Concepts – Hypothesis

- **“The imaginative preconception—a 'hypothesis'—arises by a process as easy or as difficult to understand as any other creative act of mind; it is a brain-wave, an inspired guess, the product of a blaze of insight. It comes, anyway, from within and cannot be arrived at by the exercise of any known calculus of discovery.” Peter Medawar.**
- **“The great tragedy of science – the slaying of a beautiful hypothesis by an ugly fact.” Thomas Huxley.**
- **“There are two possible outcomes: if the result confirms the hypothesis, then you've made a measurement. If the result is contrary to the hypothesis, then you've made a discovery.” Enrico Fermi.**



Science – Origin

- **“All our knowledge has been built communally; there would be no astrophysics, there would be no history, there would not even be language, if man were a solitary animal.” J. Bronowski.**
- **“... science and culture are not different entities: science is part of culture, and how science is done largely depends on the culture in which it is practised.” Maurizio Iaccarino.**
- **“... scientific experimentation is manual labor, from which slaveholders are preferentially distanced, while it is only the slaveholders – politely called “gentlemen” ... who have the leisure to do science.” Carl Sagan.**



Science – Intent, Discovery of Knowledge

- **“Science is nothing else than the search to discover unity in the variety of nature.” J. Bronowski.**
- **"Relationships between apparently different subjects are as creatively important in mathematics as they are in any discipline. The relationship hints at some underlying truth that enriches both subjects." Simon Singh.**
- **“The truth is not in nature waiting to declare itself, and we cannot know a priori which observations are relevant and which are not: every discovery, every enlargement of the understanding begins as an imaginative preconception of what the truth might be.” Peter Medawar.**



SCIENCE – What Is It

- **"All science is the search for unity in hidden likenesses." J. Bronowski.**
- **"Science is a method for deciding whether what we choose to believe has a basis in the laws of nature or not." Marcia McNutt.**
- **"Science is a way of thinking much more than it is a body of knowledge." Carl Sagan.**
- **"Science is a vision and an activity together." J. Bronowski.**
- **"Science produces ignorance, and ignorance fuels science. ... We judge the value of science by the ignorance it defines." Stuart Firestein.**



Science – Doubt

- **"By doubting we are led to inquire, and by inquiry we perceive the truth." Peter Abelard.**
- **"Even then it was clear to socially minded people that the openness of possibilities was an opportunity, and that doubt and discussion were essential to progress into the unknown." Richard Feynman.**
- **"It is imperative in science to doubt; it is absolutely necessary, for progress in science, to have uncertainty as a fundamental part of your inner nature." Richard Feynman.**
- **"Being a scientist requires having faith in uncertainty, finding pleasure in mystery, and learning to cultivate doubt." Stuart Firestein.**



Science – Dissent

- **"Dissent is the native activity of the scientist." J. Bronowski.**
- **"Dissent is the mark of freedom, as originality is the mark of independence of mind. ... No one can be a scientist ... if he does not have independence of observation and of thought." J. Bronowski.**
- **"... independence of thought and dissent are characteristics of the scientific culture, and therefore a challenge to established cultural values." Maurizio Iaccarino.**



Science – Methods

- **"We hope to discover the answer with each experiment, but we always find new questions. After doing hundreds of experiments my ignorance continues increasing to the point that I wonder if I can tell anyone anything." Stuart McGill.**
- **"With some glee and considerable professional acclaim, we seem to keep at least one jump ahead of the managers' comprehension of our methods."**
Albert R. Stage.
- **"If your experiment needs statistics, you ought to have done a better experiment." Ernest Rutherford.**



Science – Knowledge

- **"That is, if we investigate further, we find that the statements of science are not of what is true and what is not true, but statements of what is known to different degrees of certainty..."** Richard Feynman.
- **"One aim of physical sciences had been to give an exact picture the material world. One achievement of physics in the twentieth century has been to prove that that aim is unattainable."** J. Bronowski.
- **"All of science is uncertain and subject to revision. The glory of science is to imagine more than we can prove."** Freeman Dyson.



Science – Reason and Logic

- **"Through purely logical thinking we can attain no knowledge whatsoever of the empirical world."
Albert Einstein.**
- **"I say that a system which defines mass by logical construction leaves no scope for the discovery that mass is equivalent to energy." J. Bronowski.**
- **"Science is not formal logic — it needs the free play of the mind in as great a degree as any other creative art. It is true that this is a gift which can hardly be taught, but its growth can be encouraged in those who already possess it." Max Born.**

Science – Integrity

- **"The first principle is that you must not fool yourself."**
Richard Feynman.
- **"There are three creative ideas which, each in its turn, have been central to science. They are the idea of order, the idea of causes, and the idea of chance."** J. Bronowski.
- **"Without experiment, there is no way to choose among contending hypothesis, no way for science to advance."** Carl Sagan.
- **"... the idea is to try to give all of the information to help others to judge the value of your contribution; not just the information that leads to judgment in one particular direction or another."** Richard Feynman.



Values – Foundation

- **"My theme is that the values which we accept today as permanent and often as self-evident have grown out of the Renaissance and the Scientific revolution."
J. Bronowski.**
- **"If we are to choose the values that underpin scientific thinking to underpin society, scientists must think of themselves as moral leaders. But they must teach fallibility, not absolute truth." Harry Collins.**
- **"Last I shall study the conditions for the success of science and find in them the values of man which science would have had to invent a fresh if man had not otherwise known them." J. Bronowski.**

Values – Dualism

- **“The problem of values arises only when men try to fit together their need to be social animals with their need to be free men. There is no problem, and there are no values, until men want to do both. If an anarchist wants only freedom, whatever the cost, he will prefer the jungle of man at war with man. And if a tyrant wants only social order, he will create the totalitarian state.” J. Bronowski.**
- **“... man is a double creature: he is the social solitary, who needs to be sustained by his fellows yet to think alone.” J. Bronowski.**

Values – Application

- **"... the practice of science compels the practitioner to form for himself a fundamental set of universal values." J. Bronowski.**
- **"The values of science derive neither from the virtues of its members, nor from the finger–wagging codes of conduct by which every profession reminds itself to be good. They have grown out of the practice of science, because they are the inescapable conditions for its practice." J. Bronowski.**
- **"Those who think that science is ethically neutral confuse the findings of science, which are, with the activity of science, which is not." J. Bronowski.**

Values – Honesty

- **“... it follows that there is a principle which binds society together, because without it the individual would be helpless to tell true from the false. This principle is truthfulness.” J. Bronowski.**
- **“The principles of honesty, collegiality, respect for others, and commitment to dissemination, critical evaluation, and rigorous training are characteristic of all the sciences.” National Academy of Sciences.**
- **"We have constructed the thing from the data; we now deduce how the thing should behave; and if it does not, then our construction was false. What was false was not the sense data but our interpretation of them: we constructed a hallucination." J. Bronowski.**

Values – Independence

- **"Dissent is the mark of freedom, as originality is the mark of independence of mind. ... No one can be a scientist ... if he does not have independence of observation and of thought." Jacob Bronowski.**
- **The work of scientists implies that they challenge accepted explanations of facts and propose new and original ways of interpreting them. Originality, independence of thought and dissent are characteristics of the scientific culture." Maurizio Iaccarino.**
- **"I do this real moron thing, and it's called thinking. And apparently I'm not a very good American because I like to form my own opinions." George Carlin.**

Values – Tolerance

- **"Every scientist has to learn the hard lesson, to respect the views of the next man – even when the next man is tactless enough to express them." J. Bronowski.**
- **"You can get into a habit of thought in which you enjoy making fun of all those other people who don't see things as clearly as you do. This is a potential social danger ... We have to guard carefully against it." Carl Sagan.**
- **"Tolerance between people makes it possible for conflicting claims of beliefs, values and ideas to coexistence." Rivka T. Witenberg.**

Values – Self–Respect

- **"I have yet to meet a successful scientist who lacks the ability to exaggerate the importance of what he or she is doing, and I believe that someone who lacks a delusional sense of significance will wilt in the face of repeated experiences of multiple small failures and rare successes, the fate of most researchers." Daniel Kahneman.**
- **"A society holds together by the respect that man gives to man; it falls apart into groups of fear and power, when its concept of man is false." J. Bronowski.**
- **"Scientists say, 'You know that's a really good argument; my position is mistaken,' and then change their minds ... I cannot recall the last time something like that happened in politics or religion." Carl Sagan.**

Values – Imagination

- **“ Man does not invent by following either use or tradition;” J. Bronowski.**
- **"The day you've lost your curiosity is the day the world is ended to you. You no longer interact with it."**
Neil deGrasse Tyson.
- **"We have been led to imagine all sorts of things infinitely more marvelous than the imaginings of poets and dreamers of the past. It shows that the imagination of nature is far, far greater than the imagination of man."** Richard Feynman.

Value – Loyalty

- **“In loyalty to their kind,
They cannot tolerate our minds
In loyalty to our kind,
We cannot tolerate their obstruction!”**
Jefferson Airplane, Lyrics, Crown of Creation.
- **“... the loyal person acts for or stays with or remains committed to the object of loyalty even when it is likely to be disadvantageous or costly to the loyal person to do so.”** Stanford Encyclopedia of Philosophy.
- **“... loyalty helps constitute identity but is also dangerous and not something we should take lightly or rush into.”** Troy Jollimore.

Values – Harmony & Conformity

- **“Individually, scientist no doubt have human weaknesses... But in a world in which state and dogma seem always either to threaten or to cajole, the body of scientists is trained to avoid and organized to resist every form of persuasion but the fact.” J. Bronowski.**
- **"... like all Orthodox religions, they practiced rigidity that prevented them from correcting their errors."**
Carl Sagan.

Values – Hierarchies & Authoritarianism

- **“People will be more likely to simply defer to authority when they live in societies that are in fact more hierarchical.”** Frederick Solt.
- **“Hierarchy provides a psychologically appealing kind of order that clarifies roles and facilitates coordination.”** Joe C. Magee.
- **“Authoritarians prioritize social order... which bring a sense of control to a chaotic world. Challenges to that order... are experienced as personally threatening because they risk upending the status quo order they equate with basic security.”** Amanda Taub.

Values – Practice

- **"The men and women who practice science makes a company of scholars which has been more lasting than any modern state, but which has changed and evolved as no Church has. What power holds them together. In an obvious sense, theirs is the power of virtue." J. Bronowski.**
- **"It is our responsibility as scientists, knowing the great progress which comes from a satisfactory philosophy of ignorance, the great progress which is the fruit of freedom of thought, to proclaim the value of this freedom..." Richard Feynman.**
- **"Honesty requires that we recognize our own errors in reasoning, as well as those of our opponents." Joel Best.**

Scientist – Characteristics

- **"Scientists are a friendly, atheistic, hard–working, beer–drinking lot whose minds are preoccupied with sex, chess and baseball when they are not preoccupied with science." Yann Marel.**
- **"A recent study has indeed shown that, as a profession, science attracts men whose temperament is grave, awkward and absorbed." J. Bronowski.**
- **"... the body of scientists is trained to ... resist every form of persuasion but the fact. A scientist who breaks this rule, as Lysenko has done, is ignored. A scientist who finds that the rule has been broken in his laboratory, as Kammerer found, kills himself." J. Bronowski.**



Scientists – Role

- **“After all, when you’re in love, you want to tell everybody. Therefore, I find it abhorrent that scientists don’t talk to the public about science.” Carl Sagan.**
- **“... the end for which we work exists and is judged only by the means which we use to reach it.” J. Bronowski.**
- **"Perhaps that is the strength of science, and it inspiration to the young: that those who are dedicated to it are themselves creators of science – modest, creators, but creators." J. Bronowski.**
- **“Indeed, in an ideal world, experts are the servants, not the masters, of a democracy.” Tom Nichols.**



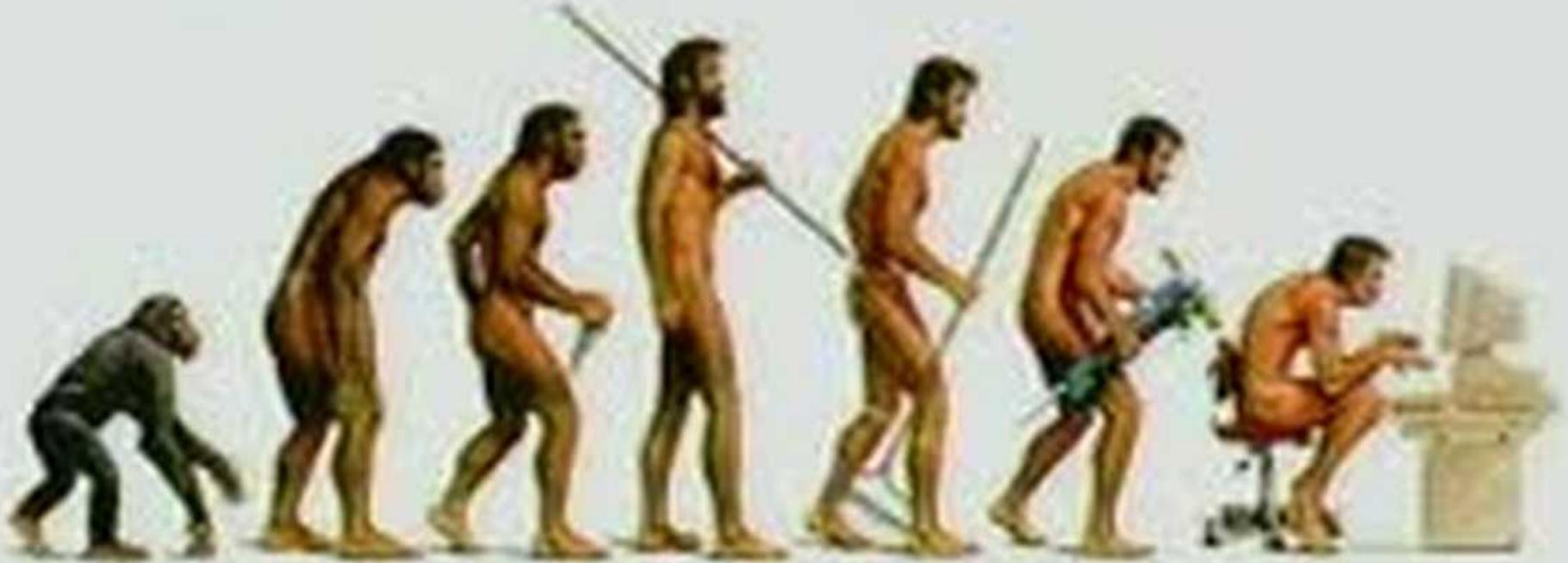
Scientist – Education

- **“It is important that students bring a certain ragamuffin, barefoot irreverence to their studies; they are not here to worship what is known, but to question it.” J. Bronowski.**
- **“This attitude of mind—this attitude of uncertainty—is vital to the scientist, and it is this attitude of mind which the student must first acquire. It becomes a habit of thought. Once acquired, one cannot retreat from it anymore.” Richard Feynman.**
- **“We live in a society absolutely dependent on science and technology, and yet have cleverly arranged things so that almost no one understands science and technology.” Carl Sagan.**



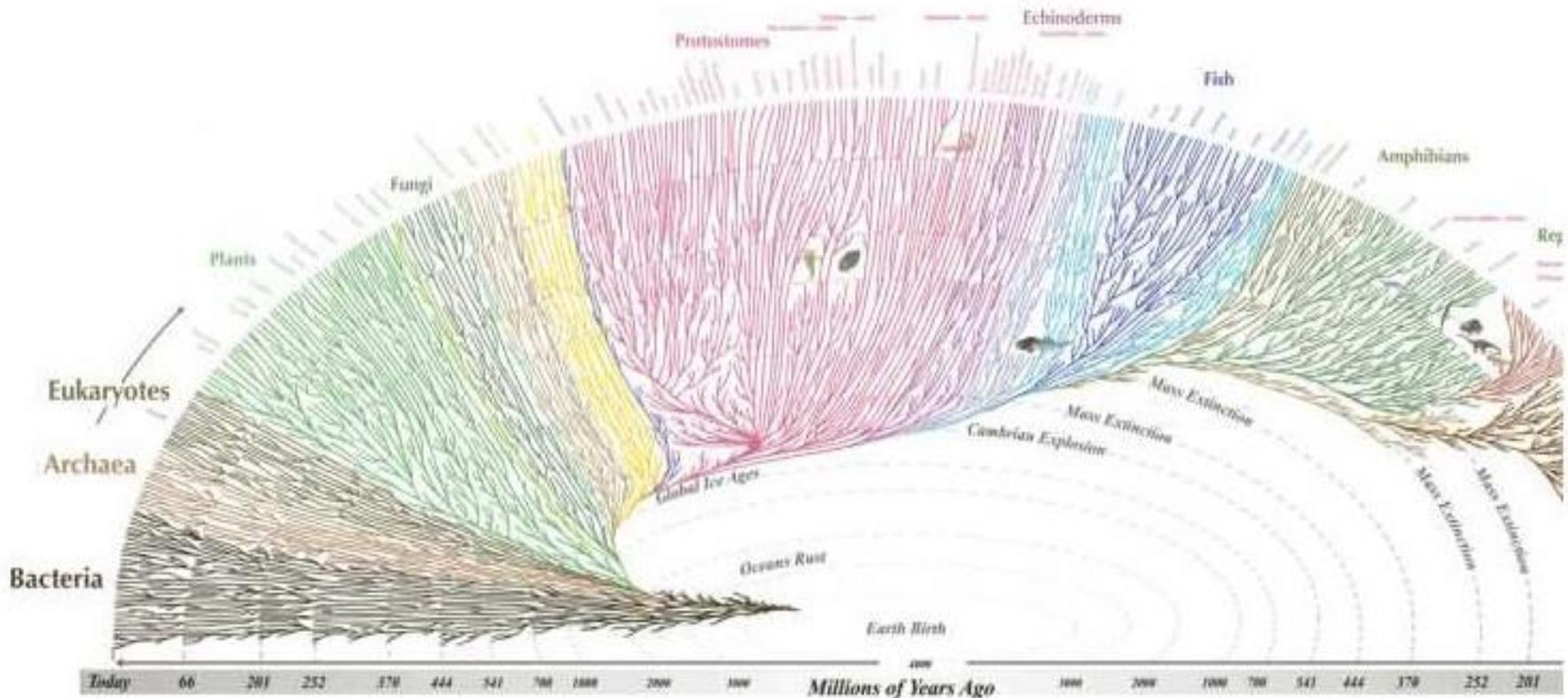
Scientist – Progress

Science is not a mechanism but a human progress.



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All the major and many of the minor living branches of life are shown in this diagram, but only a few of those that have gone extinct are shown. Example: Dinosaurs - extinct 



Regeneration Data to Share

