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Outline:

What is science?

Science is a particular way of understanding the natural world.

Science is also said to be a systematic process of seeking or producing knowledge. This process is complicated but in very general terms it involves

- observation and problem definition
- development of hypothesis,
- continuous testing and extensive peer review
- development of theories, laws or principles

But, at the same time, science benefits from some other human values like curiosity, creativity and imagination, and requires a positive attitude for being efficient and effective in scientific development.

Main features of science.

- ***Scientific outcomes are universal.***

  Science assumes that the universe is, as its name implies, a vast single system in which the basic rules are the same everywhere. Knowledge gained from studying one part of the universe is applicable to other parts.

- ***Scientific ideas or conclusions are subject to change, i.e, they are tentative.***

  Science welcomes revision of its outcomes (laws, theories, principles, standards etc) by continuous testing and evaluation, peer review or replication. In principle, any theory can change after disproof attempts and new theories may replace the old ones.

  Thus, science corrects itself. Plasticity of thought is the very essence of the scientific process. In this sense, science rejects dogmatism.

  Recall that the "quantum mechanics" replaced the "classical mechanics (Newton's Laws)" for studying the behavior of micro-particles (atoms, electrons etc) at the beginning of this century before which the behavior of all particles (micro- or macro-) were being explained by classical mechanics).

  The number of satellites of the sun is continuously changing.

- ***Still, scientific knowledge is durable enough; conclusions of science are reliable.***

  Although science welcomes change, it is not easy to change the scientific outcomes once produced by scientific standards. Note that a hypothesis is an insufficiently tested idea whereas a theory is said to be a hypothesis resisting repeated disproof attempts for years or centuries.

- ***Science can't answer all questions.***

  It has limits.

  Who can answer the question: "What is the true meaning of life?"

  Or who can provide the budget to prepare a one ton single crystal of carbon (meaning a single piece of diamond weighing 1000 kg)?

  Or who can conclude all the advances in cancer treatment at once, or in 6 months, even if we assume that we have enough funding and resources?

- ***Science demands solid evidences.***

  Science relies on verifiable, measurable, valid evidences, i.e., accurate data, at every stage of scientific process. These evidences can be gathered by measurements by and only by our senses, or the extensions of our senses (instruments).

- ***Scientific decisions or evaluations are not affected by human feelings, past experience or beliefs.***

  Development of science and scientific knowledge are not affected by human factors, like prejudices, biases, hopeful or wishful thinking, personal beliefs or priorities or preferences, nationality, sex, ethnic origin, age, political convictions, moral and aesthetic judgments and choices or religion.

  You like it or not, water has a boiling point of 100.0 °C every time, everywhere.

  Science is not democratic.

- ***Science is shaped by logic and imagination (creativity).***

  Presence of accurate data is not enough for the advance of science. Scientific concepts do not emerge automatically from data or from any amount of analysis alone. Logic (knowledge) and creativity are needed to shape them into scientific outcomes.

  All scientific inquiries must conform to the principles of logical reasoning—that is, testing the validity of arguments by applying certain criteria of inference, demonstration, and common sense.

- ***Science explains.***

  Science has the ability to show the relationships among phenomena which normally could be treated as unrelated. For example, the theory of "moving continents" has emerged by relating various concepts like earthquakes, fossil types on different continents, shapes of different continents etc.

- ***Science predicts.***

  Validation of scientific claims by observation is not enough. Theories should also have predictive power. Otherwise how could we design new powerful theories like the theory of "big bang" without using the predictive power of existing theories? In other words, how could we know that the temperature of the universe was around 1 trillion °C during the big-bang, without using the predictive power of other theories?

- ***Science is organized into content disciplines and is conducted in various institutions***

  Organizationally, science is a collection of various disciplines like chemistry, biology, engineering (with its own sub-disciplines like mechanical engineering) etc.

They differ from one another in many ways, including history, phenomena studied, techniques and language used, and kinds of outcomes desired. With respect to purpose and philosophy, however, all are equally scientific and together make up the same scientific endeavor.

This provides a ready conceptual structure for efficient research in a discipline, but has disadvantages like difficulty of communication with the rest of the world.

The boundaries between disciplines are not usually clear-cut. For example chemistry grows in the shade of physics and mathematics. It also has a big overlap with material sciences.

Sub disciplines, or new disciplines (like sociobiology) emerge from these boundaries.

- ***Science is conducted in universities, industry and government.***

  The main motivation for universities is production of knowledge, i.e., basic sciences with no immediate benefit. Industry is mainly involved in "applied science" for immediate benefit. Today, most universities are also involved in application of science (production and application of technology).

  The governments motivate both: universities for the advancement of science, and industry, for the advancement of country.

- ***Science is not democratic***

  Scientific decisions are based on evidence, not on the beliefs/preferences of the majority of people. You can not vote for the number of hydrogen atoms in water. This does not exclude the scientific discussions.

The nature of technology.

Technology is "the application of scientific knowledge for practical purposes" (Concise Oxford English Dictionary).

It is as old as human history; a stone axe was an advanced technological tool once upon a time.

It is a powerful tool in the development of civilization. Who could ignore the role of the computers, satellites, and advanced engines in today’s civic life? (research, design, crafts, finance, manufacturing, management, labor, marketing, maintenance, construction, medicine etc)

It helps us to change our world; and these "changes" may result with unexpected benefits as much as unexpected risks and costs. Nobody knew it was going to be used in mobile communication when the microwaves were invented, and nobody still clearly knows the extend of its health hazards.

Therefore, the anticipation of the "effects of technology" is of vital importance to benefit from its advantages and eliminate the disadvantages.

Therefore we need to be equipped with some background about the nature of technology to use it wisely.

Here are some characteristic properties of technology:

- ***Technology grows on science, and it contributes to science***

  It gains inspiration, or take ideas from science.

  Technology grew out of the accumulated practical knowledge (know-how) including life-long personal experiences in a master-apprenticeship system.

In parallel to the advance of science, master-apprentice system eventually left its role to "engineering".

Engineering is the "systematic application of scientific knowledge in developing and applying technology".

Engineering does not only use science, but it also uses "technology itself" and "design strategies"

Science helps to estimate the behavior of things even before production, or direct observation, and suggest new behavior of things.

Therefore, advanced technologies strongly depend on science.

- ***Engineers combine scientific knowledge with practical values.***

Both engineers and scientists think and work very similarly. Therefore, the nature of "science" and "engineering" are very similar. For example, both engineers and scientists use math, creativity, logic, and measurability (reliable evidence). Likewise, both have eagerness for originality.

Scientists make the world understandable whereas engineers make it manipulable.

Scientists can not answer all questions, engineers can not design solutions to all problems.

The only difference is that engineers can affect (change) the social system easier than scientists. In addition to scientific judgments, their decisions may involve social or personal values.

- ***The essence of engineering is "design" under constraints.***

A successful technological product includes a successful design; and a successful design involves a great creativity.

However there is no single perfect design which is safest, cheapest, the most reliable, the most efficient all at the same time. There are always some limitations either at the production level or at the application level, or at the social values level.

These constraints may be

- absolute constrains like physical laws, physical properties etc. For example silver copper is a good conductor but it can oxidise at high temperatures.
- flexible constraints like economical, political, social, ecological, ethical limitations... For example, gold does not oxidize at high temperatures but it is expensive.

Operation and maintenance costs should also be considered at the design stage. How many of us would buy a PC if we had to hire a computer engineer for the use and repair of our PC's and laptops. Doesn't this explain the success story of "user friendly" Microsoft Windows?

Thus, the technology designs should be tested before the final production by using one or more of:

- the complete product (Beta versions),
- small scale physical models (e.g., pilot plants)
- computer simulations (safer, and cheaper)
- analysis of analogous systems
- testing of separate components only

- ***All technologies involve control***

  Control is necessary for "proper operation".

  Control requires:

  - feedback (from sensors or other sources of information)
  - logical comparisons of measured data to standards/instructions
  - a means for activating changes

  Today microprocessors are widely used as control units.

  Rapid communication and rapid processing is essential for complex control systems.

  All control systems require human control at some point. Live human intelligence should be able to interfere automatic control systems at any level to prevent for example the false alarms due to unprogrammed parameters, or parameters whose effects are no longer valid.

- ***Technologies always have side effects.***

  Every design may have unintended side effects.

  They may be beneficial (e.g., safer) or harmful (e.g., increasing the unemployment rate with increasing automation)

  Side effects are not limited to nuclear reactors. Small technologies' side effects may seem to be ignorable but they may have significant cumulative effects (like contribution of refrigerators to global warming).

  Prediction of side effects is not easy, sometimes impossible. Systematic risk analysis is needed.

  Risk analysis and even the definition of the risk is complicated, and sometimes is very expensive.

- ***All technological systems can fail.***

  Most modern technologies are fairly reliable. Yet, the reliability decreases as the complexity of the design increases.

  So called "fail-safe" systems are designed for technologies having costly consequences if they fail. For example, it is very difficult to prevent car accidents but it is possible to lower the injuries or death incidences by using safety windows, or air-bags.

  Possibility of failures can be reduced by collecting more data, using more variables, building more realistic models, doing computer simulations, using tighter quality control, and building auto-correction systems.

- ***Human presence is an important issue in technology.***

  We, the human beings, have the capacity / ability to dominate the nature and "shape the future" rather than just responding to it.

  This ability (through the use of technology) has the following advantages and disadvantages:

  Advantages: cheaper and easier access to goods and services and comfort (transportation, communication, nutrition, health care etc..)

Disadvantages: new risks both to us and other species (pollution, ozone layer, global warming etc..)

We now depend on nonrenewable energy (petroleum, coal) and mines. There are serious environmental problems.

Other species, e.g., birds, plants etc., suffers more from the negative consequences of technology and human presence. From their standpoint they now have less areas of vegetation, less food sources, poorer habitat with changed temp and composition, destabilized ecosystems by foreign species, more altered characteristics by genetic engineering. Hence, the number of species is continuously decreasing on contrary to the rapidly developing human population (3 times in the last century).

However, we have enough reasons to conclude that the human intelligence will also solve these problems.

Fundamental characteristics of scientists

- ***Scientists are conducting science as a complex social activity.***

  Scientists, men or women from all nations or ethnic backgrounds are involved in development or applications of science, and their cumulative power have strong impacts in the society or development of their own country or territory.

  Scientists work in various places like universities, hospitals, business and industry, government, independent research organizations, and scientific associations. They may work alone, in small groups, or as members of large research teams.

  Their places of work include classrooms, offices, laboratories, and natural field settings from space to the bottom of the sea.

  They communicate with each other or other segments of society through special communication tools like publications in scientific journals, conferences, books, internet forums or blogs, professional associations etc. They form national and international networks for better collaboration. They also form interdisciplinary networks for sophisticated scientific products.

- ***Scientists are responsible, honorable and trustworthy individuals; they conduct science through ethical principles.***

  Strict ethical principles are carefully, respectfully, and proudly followed by scientists in order to keep the science on top of the most valuable human assets.

  Scientists posses scientific integrity in their lifestyles. Within this context:

  - they have a commitment to intellectual honesty, and they act responsibly,
  - they never deviate from accuracy (cheat) for the sake of no human benefit,
  - they represent collegiality in scientific interactions, including communications and sharing of resources
  - they demonstrate transparency in conflicts of interest or potential conflicts of interest,
  - they protect human subjects, animals and environment in the conduct of science and research,
  - they adhere to mutual responsibilities between their own teams and other scientists or researchers.

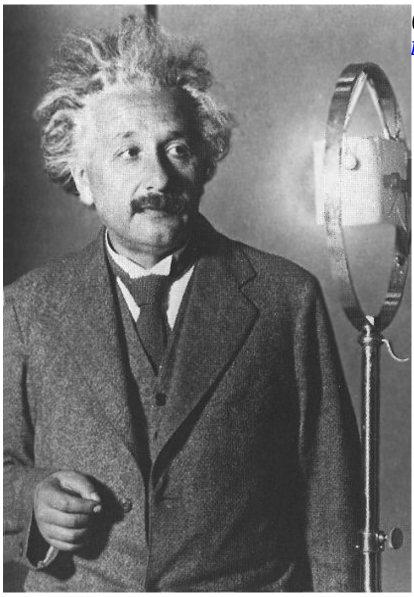
  Otherwise, how could we trust on science and scientists?

Ethical issues are very important in science, therefore, this topic will be covered on a separate chapter within this lecture.

- ***Scientists not only serve science, but they are also involved in public affairs as experts or knowledgeable citizens.***

They have an advisory role, hence, they lead the society itself, or leaders, or administrators of the society by helping to differentiate between the "facts" and "opinions", or "true" and "false", or "possible/probable" and "impossible".

Thus, their opinions are treated/perceived as "truth" by ordinary citizens. Therefore, they need to be careful on declaring opinions such that they don't mislead the society on the issues they do not have enough expertise.



(Albert Einstein during a radio talk, from http://th.physik.uni-frankfurt.de/~jr/physpiceinstein.html)

- ***Scientists think critically (scientifically). (Scientists are good scientific thinkers and problem solvers)***

Critical thinking is actually a broad term including the scientific thinking which can also be owned or applied by nonscientists. It serves as a base for the "scientific method" (which will be covered on a separate chapter in this lecture).

Critical thinking means "correct thinking" for reaching or producing relevant and reliable knowledge, conclusions, beliefs or values.

A person who thinks critically can ask appropriate questions, gather relevant information, efficiently and creatively sort through this information, reason logically from this information, and come to reliable and trustworthy conclusions about the world that enable one to live and act successfully in it.

A critical thinker can focus, identify and clarify problems and issues, and try alternative ways or methods to solve them.

A person who practices critical thinking can achieve a productive, successful, ethical, happy, and, ultimately, a satisfying and fulfilling life or profession.

Critical thinking assures correct or closest to correct knowledge by welcoming thinking styles like:

Rational (logical) thinking, empirical thinking, skeptical thinking, pragmatic thinking (recognizes that wishes and hopes do not make a belief true or even worth holding.), reflective thinking (stopping and revising the basis of your beliefs), creative thinking (ability to think in new and innovative ways), comprehensible thinking (using empirical, repeatable, testable, verifiable, analyzable and objective evidence for firm conclusions), reasonable thinking (emotions are not evidence, and feelings are not facts), quantitative thinking (using quantitative terms to describe the nature), analytical thinking (a conscious and reasoned process of analysis, clarification, comparison, inference and evaluation), statistical thinking.

Without critical thinking our beliefs, evaluations, or conclusions could be falsified by the catalysis of some ordinary thinking styles (mostly harmful at scientific level) like:

> *illogical thinking, intuitive thinking (superiority of mind's power), hopeful/wishful thinking, authritarian thinking (unquestioned acceptance of knowledge by an authority figure or institution), dogmatic thinking (resistance to accept new knowledge or change), idealistic thinking , absolutist thinking (black or white thinking), close-minded thinking (reliance on old), mystical thinking, emotional thinking, qualitative thinking (using ambiguous and imprecise qualitative terms) etc.*

Critical thinking is essential for scientific practices, in other words, there is no alternative for the scientists and researchers.

Critical thinking could be learned in childhood only from the parents or teachers. Children can not learn the critical thinking by themselves, from peers, or by their mistakes.

A proper undergraduate education will help to improve one's critical thinking skills. At graduate level, you can continue to improve your critical thinking skills by continuously and consciously testing and evaluating your scientific practices and keeping them within the range described here in this section.

As stated above, rational (logical) thinking, empirical thinking and skeptical thinking are the most basic characteristics of critical thinking:

Empirical Thinking, or Empiricism : The Use of Empirical Evidence

As mentioned earlier, an empirical (experimental) evidence is the only type of evidence used by scientists and critical thinkers to make vital decisions and reach sound conclusions. They are not interested in ad-hoc hypothesis; i.e, they do not base their arguments on spiritual claims like Elves and Gnomes.

Logical Thinking, or Rationalism: The Practice of Logical Reasoning

Logic allows us to reason correctly. Logic can be learned through education (either through taking logic courses, or taking science courses; especially Mathematics).

The use of logic is not easy. Logical reasoning may even be painful since it may require fighting with your inner world, and sometimes deny your feelings. Thus, true scientists are conscious enough about this phenomena, and know how to stay away from wishful, hopeful, or emotional thinking.

Furthermore, the scientists are conscious enough about logical fallacies and faulty reasoning. They are not trapped with false logic, falsehood and misconceptions.

Here are some common sources of logical fallacies

- **Incorrect assumption of cause/effect relationship (**For example: "every time I wash my car, it rains; therefore, if I wash my car, it will rain."

- **Inaccurate or distorted use of the interpretation of numerical statistical information** Example: "Fatal traffic accidents decreased by 83 % after increasing the traffic fines (monetary penalty) the last month." (1 month statistics is not comparable to years' statistics. Drawing such a conclusion requires at least 1 year measurement)

- **Faulty analogy, comparison carried too far, or comparison of things that have nothing in common**. For example "Apples and oranges are both fruit and grow on trees; therefore, they taste the same" - **Oversimplification**. Potentially relevant information is ignored in order to make a point. Example: (No color change was observed; therefore compound A and B does not react" (What if the product is colorless? Or if you are sure that it is colored, then have you tried at other reaction temperatures?)

- **Stereotyping**. This is the application of an over-simplified label to entire group of people or objects. Example: "All Hispanic Americans speak Spanish; therefore Spanish language advertising will appeal to all of them.

- **Ignoring the question, digression (deviation from the main point), obfuscation (lack of clarity, confusion) are used to avoid answering a question**. For example, "When asked about a tax increase possibility, a politician replies, - I have always met the obligations I have to those I represent.!!"

- **Faulty generalization**. It is a judgment based on insufficient evidence. Example: Ducks and geese migrate south for the winter; therefore, all waterfowl migrate south for winter.

<u>Skeptical thinking, or skepticism: Possessing a skeptical attitude</u>

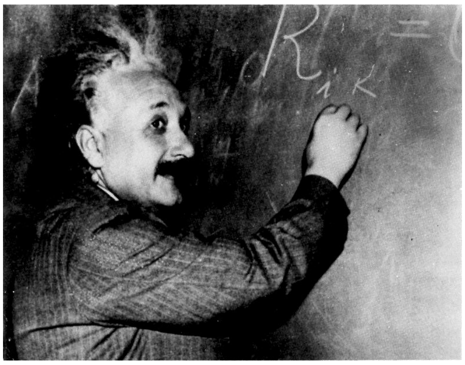
Scientists repeatedly and rigorously examine (question) their beliefs and conclusions in order not to be trapped by self deception or deception by others. Self deception is a very common human failing, especially among ordinary, uneducated people. The problem is that it goes unrecognized since nobody wants to deny themselves.

Thus scientists compare the logical consequences of their beliefs with objective reality (as measured by empirical evidence). If they match, the scientists conclude that their beliefs are reliable knowledge, i.e., their beliefs have a --you can conclude that your beliefs are reliable knowledge (that is, your beliefs have a high probability of being true.

Some people believe that scientists are close-minded, i.e., they resist changing. But just opposite is true, "true scientists" are undogmatic, and they are willing to replace their old beliefs when there are more reliable evidences or sound reasons for change.

- ***Scientists are eager to learn and teach.***

Learning and teaching are key concepts in the life of a scientist.



True scientists always reserve a time slot on their weekly schedule for following the literature to update themselves with the latest developments in his field.

Likewise, true scientists see "teaching" as an integral part of their profession. They like to share their knowledge with their students, colleagues, and society whenever necessary.

- ***Scientists learn from each other (Scientists are good communicators).***

That is the reason why scientific seminars, conferences, and workshops are common practices in scientific community.

That is the reason why we have thousands of scientific journals.

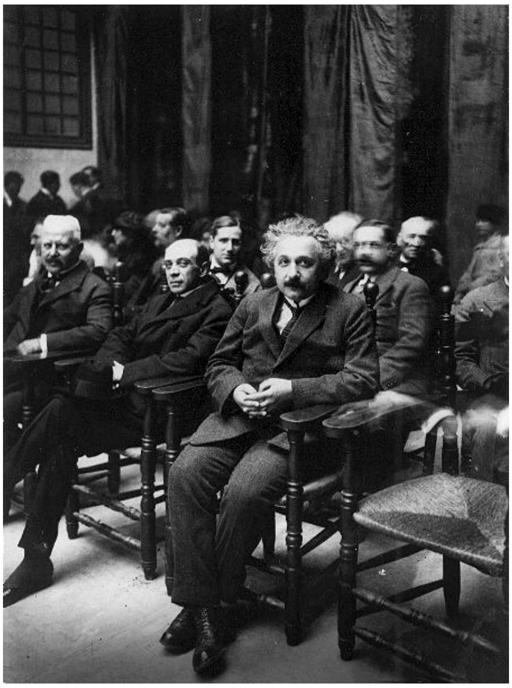
The term "secret information" does not go along with scientific manner except for theca cases like commercial or military research.

Scientists serve to each other as peer reviewers in thesis defense juries, paper manuscript presentations, financial fund applications, etc.

Formal or informal discussions are favored to guard the scientists from unforeseen errors or mistakes, as well as they provide the fuelling effect of common knowledge and synergy, develop new ideas and critical thinking skills.

"Discussion" or "arguments" suggests a "fight" or a manifestation of power, or an aggressive conflict where one tries to dominate the other, or simply "win" in everyday life. In other words, for ordinary citizens, a discussion is often a totally "humanly emotional" activity. However, in science, this kind of "personal" arguments are not appropriate. It is not important who "wins" -what matters most is the quality of argument itself.

Scientific discussions among true scientists may sometimes be very rigorous, and they may even seem to be hurting, but they are practiced through some scientific discussion etiquette rules. These rules will be summarized elsewhere.



(Albert Einstein listening to a colleague in a seminar. From http://th.physik.uni-frankfurt.de/~jr/physpiceinstein.html)

- ***Scientists work systematically***

No invention is all of a sudden in science. "Eureka" sort of discoveries are of historical (or better "nostalgical") importance. Today, even very small discoveries are done by having carefully designed procedures or road maps. Research proposals having a small ambiguity in the design of method and experiments are easily rejected.

- ***Scientists seek originality***

They are eager to dig the universe for exploring "unknown" or "new" or "unique", i.e., originality. It could be originality in the tools, techniques, and procedures developed, originality in exploring the unknowns, originality in the products (outcomes) or byproducts, originality on the use of data and so on.

This topic will be covered in more detail since originality is a "must" in graduate science, and a graduate student should comprehend it clearly.

- ***Curiosity and a positive attitude is the fuel of scientists.***

  Scientists see the universe through questions (curiosity), and attempt them to answer them. A positive attitude is a must for productivity and effectiveness.

  Who can manage to put a person into the laboratory if he believes that "he can't do it"?

  We will discuss the role of a positive attitude and attitude development skills elsewhere in this lecture.

- ***Creative thinking is a powerful tool for scientists.***

  Scientists do research. Research is a form of problem solving. Creativity is a means of increasing the productivity and efficiency of problem solving.

  Creativity is especially useful when new ideas are needed. This includes both the generating of ideas when identifying a research topic and overcoming setbacks that often occur during the research.

  Use of creative thinking activities encourages looking at the research topic or problem from a broader perspective.

  Creative thinking skills can be improved.

<u>Creativity Inhibitors</u>

Inhibitors are factors that limit one's use of his or her creative ability.

The attitudes "**I am not creative**" or "**I cannot improve my creative ability**" are examples of creativity inhibitors.

Other examples of creativity inhibitors include t**he fear of questioning, exploring new ideas, making mistakes, experiencing failure, and taking risks**. Overcoming such fears through a study of creativity is the first step toward success in improving your creative ability.

There exists a common myth: "One's creative ability is set at birth and it cannot be developed". In some cases, this myth becomes a crutch that people use to avoid self-improvement. In fact, studies have shown that individuals can improve their creative ability by learning creativity enhancement techniques and by adopting a positive attitude toward creativity.

Another myth about creativity is that some people have it and others do not. While this is a common belief, all studies of creativity suggest otherwise. In fact, it is often this belief that hinders individuals from succeeding in research. They develop a mental block against creative idea development because they believe that they lack the capacity for creative thought.

<u>Creativity Stimulators</u>

What factors have influenced your current level of creative ability? Many factors are responsible, including y**our intellect, your life experiences, your attitude toward creative problem solving, your curiosity, your willingness to persevere, and your knowledge of and ability to use creativity stimulators, i.e., creative problem-solving methods.** Your creative ability improves whenever you improve any one of these factors.

The first step toward improving your creative ability is i**mproving your attitude about the value of creative problem solving**. Obviously, if you approach the topic with the attitude that it isn't important or that creative ability cannot be developed, then it is quite unlikely that you will become more creative. In this case, your attitude is a creativity inhibitor. Even the attitude that you will explore the possibility that you can become more creative is a step in the right direction. Once you have adopted a positive attitude, you will be more open to using creativity stimulators, which are methods that can be used to generate creative ideas. While a number of stimulators or technics are used, some will be briefly outlined:

- ***Talking things over*** - Talking things with other people does not only provide the benefit of their views and ideas, the very act of talking seems to stimulate one's own thinking. The other person does not necessarily be of the same field, or the expert of the field. Talk with other colleagues or friends. If you have nobody to talk, talk yourself.
- ***Keeping an open mind*** - It is a fundamental to all research. It involves identifying all the unlikely or seemingly implausible interpretations and then considering them carefully to see if they might have any validity. Keeping an open mind is particularly important when talking to others; without it, one is liable (responsible) to 'hear' (i.e., 'take in') only what one already knows.
- ***Brainstorming*** - Useful particularly in problem solving in groups.
- ***Negative brainstorming*** - listing as many ways as one can think of about how *not to achieve* a purpose, and then, when the list is complete, considering whether reversing any of them might be productive. This method may seem to be ridiculous (absurd, meaningless) but, however, it is very effective in producing "ideas" that would never have been thought of via more direct methods.
- ***Viewing the problem from imaginative perspectives*** - that frees the mind from constraints which may have handicapped its creativity and which may in practice not be as convention and normal expectations have led one to expect. Technic involves asking or defining preposterous (unbelievable, absurd, seemingly impossible, ridiculous) questions or problems and trying to solve them. Some may end up with worthwhile results.
- ***Concentrating on anomalies*** - it involves the reconsideration of anomalies (abnormal, unexpected, outlying results) if they offer anything worth of exploring or investigating.
- ***Focusing on byproducts*** - the solution may be hidden in the byproducts. Do not waste your data easily.
- ***Interrogating (collecting evidence through questioning) imaginary experts -*** Prepare a list of questions as if you are going to interview an expert of the field. The interview does not have to take place.
- ***Viewing the problem from the perspective of another discipline*** - Talk the problem with other people from other fields and see how they approach. Or examine (learn) that discipline approach the problem from the point of that discipline by yourself.
- ***Using 'the solution looking for the problem': serendipity*** *(ability to make valuable discoveries by accident)* - to keep one's eyes and ears constantly open, to question anything and everything to see if it might be used to provide a creative leap (jump) forward.
- ***Using mind maps -*** freeing the mind from the constrained and ordered viewpoint from which it has been seeing a problem or issue. It provides an overview, which shows at a glance all the components of the problem or issue and the links between them.

- ***Scientists are patient***

  They may repeat the measurements several times. Steps may be tough, boring or not pleasant.

- ***Scientists are detail-oriented***

  Close attention / focus on the details of the data is a must in science.

- ***Scientists have refined aesthetic notion***

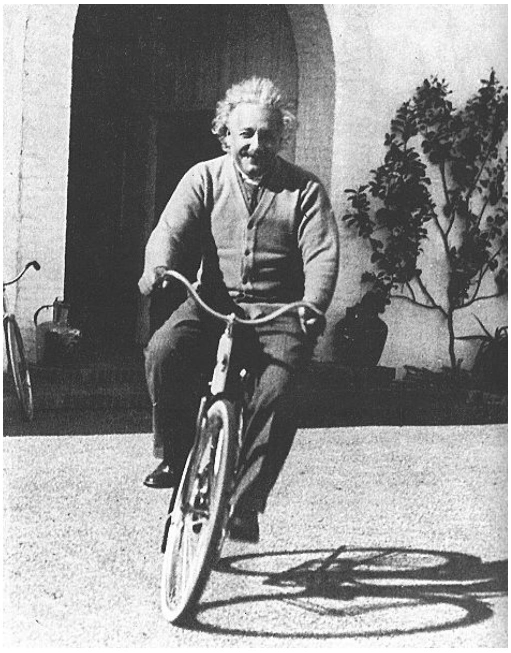
Scientists appreciate beauty, i.e., they are usually very close to art and artists.

This explains why most of the universities teach arts and science topics in a single faculty named "Faculty of Arts and Sciences"

- ***Scientists can't answer all questions yet***

This is not a shame. Science is still developing and will continue to develop as long as human curiosity exists.

- ***Scientists are human beings!!!***



There is a famous humor saying that "scientists live in ivory towers" meaning that thinking- and life-styles of scientists are totally incompatible with ordinary people, therefore, they isolate themselves from the rest of the society.

That is not true at all.

True scientists also have all human feelings. They also love, hate, enjoy, get angry, scream, joke, belive, suffer, win, gain, loose, struggle, vote etc as much as ordinary citizens do... They can also fail in in their decisions, even in their academic life.

Albert Einstein and his bicycle,
From: http://th.physik.uni-frankfurt.de/~jr/physpiceinstein.html)

Prof. Richard Feynman, playing Bongo Drums. From: http://ysfine.com/feynman/fphoto.html

Reading the book titled "Surely you are joking Mr. Feynman" is strongly recommended. It demonstrates how a Nobel Prize winner (Richard Feynman, Physics, 1965) can enjoy life, and convert his curiosities to joy.

(*Surely You're Joking, Mr. Feynman!: Adventures of a Curious Character*, Richard Feynman, Ralph Leighton (contributor), Edward Hutchings (editor), 1985, W W Norton, ISBN 0-393-01921-7, 1997)

- ***SCIENTISTS DO RESEARCH***

That is what the rest of this lecture all about.