Introduction to Professional Scientific Communication
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Lecture – 03
Inductive vs Deductive Reasoning

So, welcome back to this course professional scientific communication, in this lecture we are going to look into as to how you develop hypothesis right. So, what is shown on the slide is the 2 distinct way of reasoning.

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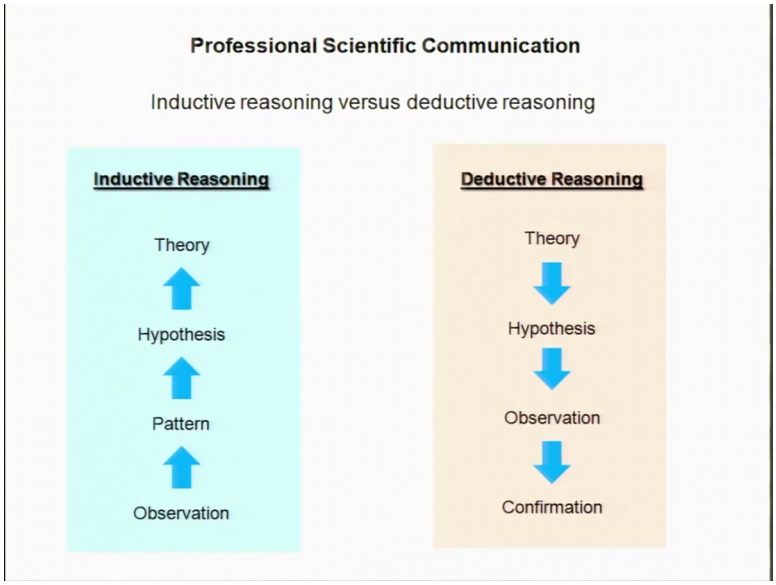

Meaning observing something and making a meaning out of it, 1 that is shown on the right side is called as inductive reasoning you observe something from your observation, you find that are there are patterns based on the patterns you have develop an hypothesis and then evolve what is called as a theory ok.

So, this is 1 way of doing science by you know looking at certain patterns from the observation that you are made. So, when you observe in this particular aspect what you call as a inductive reasoning; you really do not have a preconceived notion as to what you should look or what possible it means you only observe everything that is there and see is there any patterns and whether the patterns you know mean something then you develop an hypothesis which may be true which may not be not be true, but it is a convincing that is what called as inductive reasoning.

This is a different school of thought the although, now you do not call it as a different school of thought we will you know try to bridge these 2 little later, but a different school of thought is called as detective reasoning, meaning you have a theory which is either proposed by you are proposed by somebody or you looked at the literature you come up with a kind of a theory and you develop an hypothesis for your research..

You know project thesis whatever and then based on a hypothesis you do certain experiment to test the hypothesis to validate the hypothesis and you have an observation and then you confirm that your hypothesis was right therefore, these were facts right. So, from theory to sort of confirm and other thing you have observations to upfront you start with and then come up with certain theory. So, these are possibly 2 distinct schools of thoughts if you really look in that perspective, but may not be. So, in the long run I will discuss little later.

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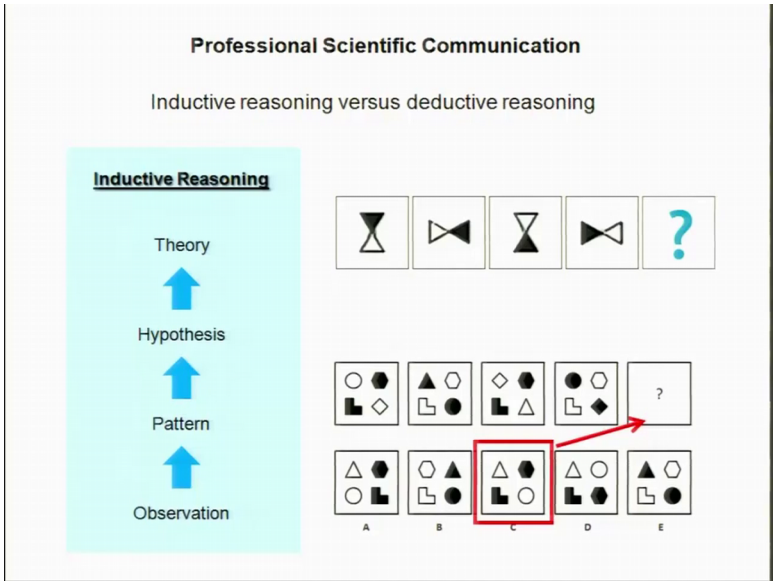

Let us look into this inductive reasoning, for example this kind of you know patterns that are very common in most of the in exams that would be attend attending, you basically look at as to what should be the next you know pattern that should be there on the fifth you know square that is now marked by a question mark right. You know that when you by looking at the pattern it look like that hour glass is rotating. Therefore, what you expected something what is shown on the ferry first square it should be repeated. So, this

is you know inductive reasoning, by looking at patterns we infer something that is called as now hypothesis or theory. So, you can apply very similar thing to little more complex.

For example here there are different symbols each 1 whether it is filled or filled then there are different combinations that are there. So, you have to look at how this square want you know changes in the square 2 3 4 and so on and you to sort of guess as to what should be the pattern you expect in the fifth you know square that is shown there. So, by looking into this pattern you can say that, you know alternate with l shaped symbol that you see at the left lower corner starts with the filled symbol then it becomes unfilled again filled unfilled.

So, the next 1 should be filled that is what your reasoning is and if you look into there are at least 3 sets you know squares that are with filled k sorry, 1 other lowest is A C or D right. So, then you have to think off which one of them and then you have to see that opposite you know corner also is a filled one and with that reasoning you say that for a possibly the C is a 1 that should come there by some reasoning that you come up with and do that for this is by looking at the patterns you sort of predict that is what called as you know hypothesis and it could be true so.

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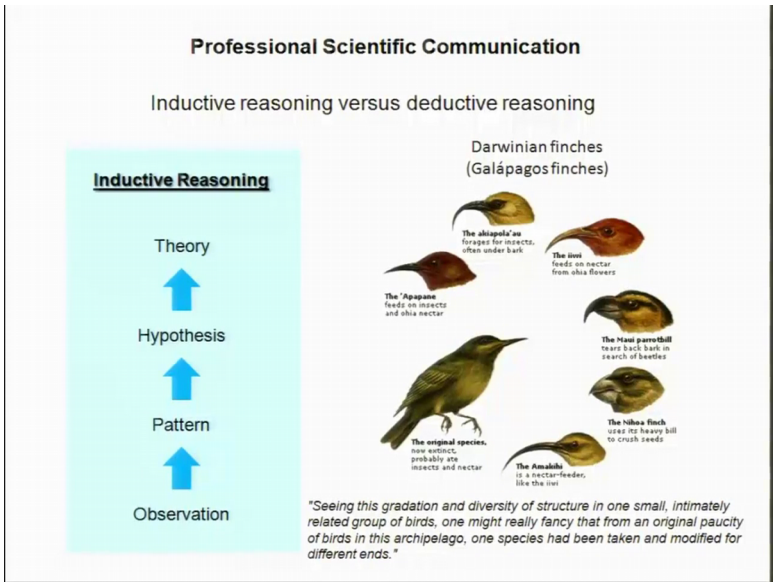

The inductive reasoning is the process where a small observation; used infer a larger theory without necessarily proving it.

Given example evolution so, evolution is something that happens over millions of years. So, it is impossible for any scientist to live through as many years to see the process you know and observe document and say. So, most often what you do is these are looking at certain patterns you come up with certain theory which you know you say as you know this is possibly happening, when you talk about the theory of natural selection is 1 such you know kind of theory that has come from inductive reasoning, which is very very difficult to you know test real time because evolution takes age is to you know sort of undergo changes.

The other good example is the again contribution from Darwin, is the Darwinian finches these are you know the you know kind of birds that were you know present in the in the in the island called Galapagos and Darwin went there and observe them and if sort of you came up with an idea that all of them you know have different beak shapes and size and all of them should evolved from 1 particular common species..

So, he sort of proposed idea what is called as adaptive radiation because, you know you count a new island is a different environment you do not want to compete there are different you know places, we can get you know food and so on. So, they evolved change depending on the habitat the place they were dwelling right.

Seeing this is what that the little text that is shown at the end in the bottom of this particular you know slide, he is the you know verbatim I copied from the book of Darwin the natural selection seeing this gradation and diversity of structure in 1 small intimately related group of birds, 1 might when he what he refers to the structure is the big 1 might really fancy meaning we can think of..

Imagine that from an original positive birds in the archipelago 1 species has been taken and modify for different and it is meanings 1 particular species k means settled and then they populated different parts and then they gradually you know you know undergone some changes now you have distinct species that was his theory.

Now, you know that that is not just theory now it is proven that indeed, all these birds evolved from possibly a common ancestor with lot more scientific you know you know support right. So, that really tells you that inductive reasoning can help you know in science and you some of these hypotheses that you we have theories we have how come from inductive reasoning.

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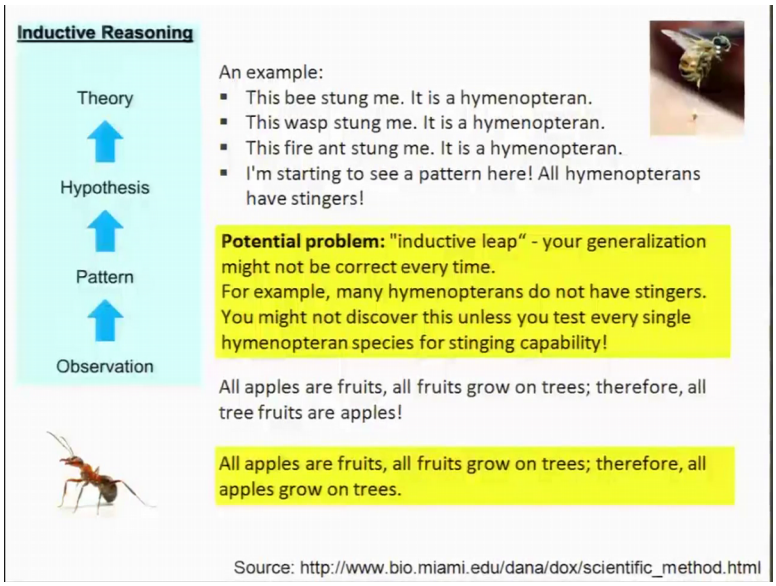

However, inductive reasoning can have it is own limitations, I will give you some examples again these are borrowed from a very interesting link that is shown on the bottom of the slide, for more details I would recommend that you go and read the original text I have borrowed it from that particular link.

For example you know you are talking about the honeybee which is shown on the right corner top, corner which you know you know insect which can sting you right this is this bee stung me and you know you are a biologist you are a geologist you know that it is a it belongs to a group called hymenoptera; then it is not bee you also have wasp that can also sting. So, this wasp stung me it is hymenopterans and again this fire ant stung me it is a different insect again that belongs to the same group called hymenopterans. So, based on these 3 successive in encounter with insects that stung me; which is painful event.

I came to the conclusion that that does a pattern there you know 3 distinct species all stung all painful equally in all threes, you know insects belong to hymenopterans group. So, therefore, I can say all hymenopterans or the insect that belong to this group have stingers meaning they can painful when this sting right. So, that is the pattern that is a hypothesis theory I can make, but it can you know what is to test let us look at some other example. For example, all apples are fruits all fruits grow on tree therefore, all tree fruits are apples again there are limitations we will come back to that little later.

Let see this potential problem by looking at certain pattern and making certain theories or assumptions that could be wrong, inductively that is what called your generalization might not be correct every Darwin was right time tested, but it may be true for everything. For example, the many hymenopterans right do not have stingers for example, and that you look at they do not have sting like they do not sting like the bees, they can use their mandibles to bite you they can only bite right.

They so you now, therefore unless you take every insect that belong to the hymenoptera species put on your hand and see whether it can sting or not sting it is not a good experiment, you are unable to confirm or really support your hypothesis that all hymenopterans are stingers right. Therefore, the limited pattern that you see cannot stretch it; further unless you are done exhaustive study right.

Let us look at the other examples all apples are fruits all foods grow on tree therefore, all apples grow on tree is you know may not be there the best way to explain that it cannot be that every food that you see in a fruit is an apple. So, that this limitation in that. So, how do you really do, so this is what we explain inductive reasoning you observe you find certain pattern based on the pattern.

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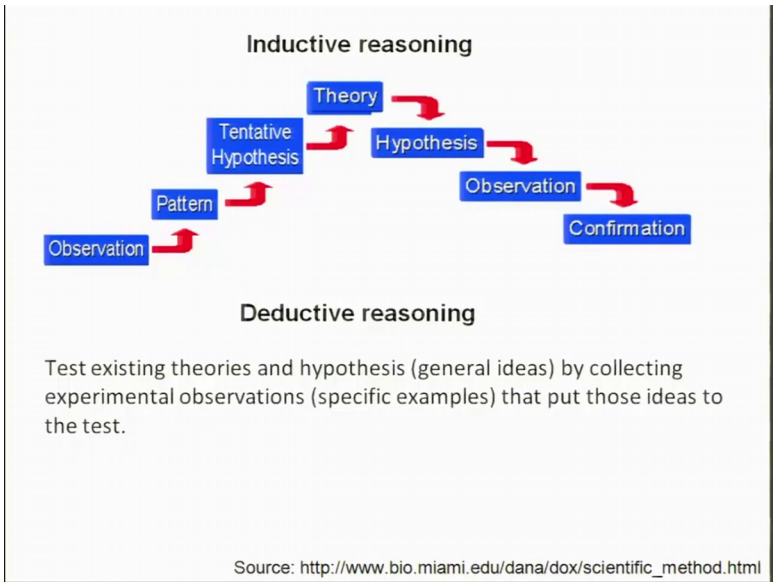

You evolve an hypothesis and the hypothesis if it is attractive many suggests or support that then it becomes a theory like.

For example the natural selection now it is still the theory, but it is time tested are widely accepted right now that is called as inductive reasoning, but there is a you know you know for this to be true you need to test like what I said, all hymenopterans are stingers what you need to do you know go and collect has many insects that belong to that group and then test whether they really sting, so that is what called as detective reasoning..

So, you have a theory or on hypothesis, hypothesis the, that how will hymenopterans or stingers and then you test it. So, when you do a deductive reasoning what is called as you should test the hypothesis you should be able to test the hypothesis and carryout from experiments you observe that is called as observation and the observations would confirm that your hypothesis was correct and then you come up with what is called as detective reasoning.

Test existing theories and hypothesis general ideas, by collecting experimental observation specific examples that put those ideas into the text that is called as detective reasoning. So, when you do this anyone could repeat your experiment should be able to get almost similar you know observations. So, that is what when something is proven the hypothesis become sort of law..

For example, the theory of Mendel became now you call as law of segregation law of independent assortment you call it as a law now is because, this has been rested many a times by many experiment when tell it is and you are able to get predict what would get and you do get right that is what called as now deductive reasoning.

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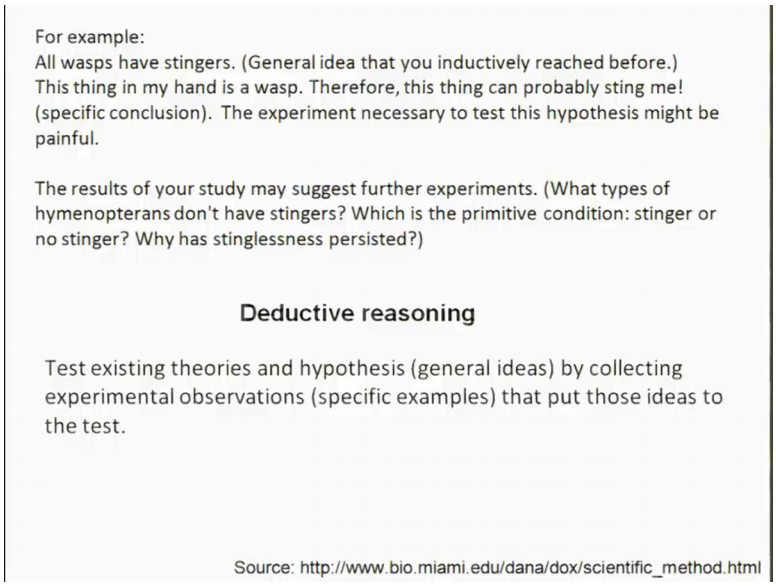

So, what you do so all wasps have stingers that is what I will give example right, all these are general idea that inductive inductively reached before right. So, this is certain minimal number of patterns with which you are able to you know generate an idea and then you have to test that is exactly what I have explained just now. So, the results of your studying a suggest further experiments always it happens, remember I said that that is an infancy to an hypothesis you do experiments you get rapidly reserves and then you sort of heat a plateau where you cannot go any further again you have to evolve hypothesis take it further right.

So, therefore, always experiments lead to some observation which would demand for the experiments right and therefore, you know you have to go and do redo do more experiments and take the you know research forward right, that is precisely called as detective reasoning; most of the scientific discoveries are not all being carried out using the detective you know reasoning. So, you know the in other words induction is called as possibility.

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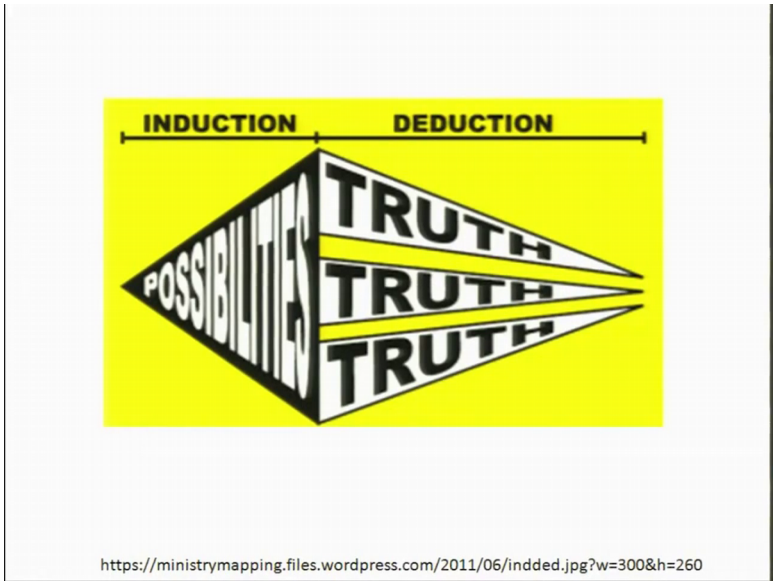

you know inductive reasoning based on patterns you suggest some possibilities and the possibilities are tested by detective reasoning and then you say this is what the fact is like; now you talk about genes being inherited from you know father to the next generation mother to the next generation is now know that it does happen right.

So, but this is something that mentally told much before anyone could think off, therefore it was then called as hypothesis are you know theory now you know it is law because, it does happen that becomes a true. So, that is how the science evolves. So, let us see the difference between different you know definitions you call hypothesis you call theory and you can law.

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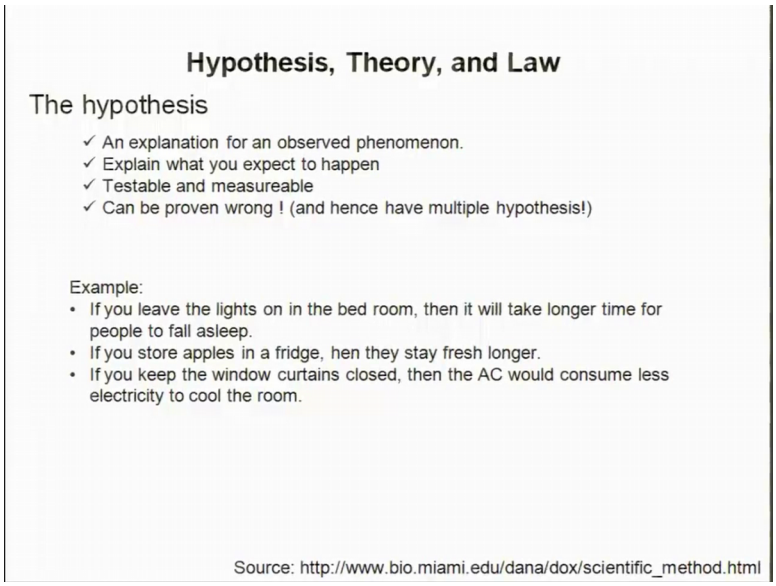

So, at times we change this you know statement hypothesis into theory or theory into law and. So, on, but each 1 has got specific definition and therefore when you say something you should know what you are saying is a hypothesis or a theory or a law and as to why you should say so.

Let see first the hypothesis, hypothesis is an explanation for an observed phenomenon. So, you have observation either you are made yourself or you find you know the literature that people have done experiments they have these results. So, based on the result that is observation you come up with a hypothesis right; explain what you expect to happen you say that this is what it is.

For example this is a gene and this gene is expressed when I am exposed to a given pathogen, therefore you know this gene when it expresses it inside protect me from the infection say let say this is hypothesis. So, if this is the hypothesis then you expect something what do you expect, if I am expose to the pathogen the gene should be expressive, so that is expectation.

So, therefore, you can test that and you can measure is it really the expression level gone up, is it really that the gene is turned on when I am infected with certain bug and importantly it can be proven wrong because that is very important my hypothesis maybe absolutely wrong maybe attractive, but is then I test that I will find that that is not possible it is happening. So, what I do I do not feel sorry I go back read more think more

I come up with alternate hypothesis which again can be tested I do, that is why there is a lag period when you have certain observations then you have to identify alternate hypothesis, you have to do more experiments and 1 of the hypothesis would give you lead again to take a quantum jump..

So, therefore, you know failure is not considered to be failure in that sense, because it helps you to go move to an alternate hypothesis therefore, failure you know is as important as success in science.

Let see some of the examples which you know now there are statement again they have taken it from the link that is shown below, if you leave the lights on in the bedroom then it will take longer time for people to fall asleep right; it may sound like how it is true but let us say that it is testable it looks very attractive because the lights are on I cannot close my eye we will still I could feel the sensation, therefore I do not sleep if it is dark I sleep right before I can test it I can have 2 different rooms 1..

I can have the lights on in other I can turn off the light and see in which room people sleep early quite testable hypothesis, then I can say indeed that is the case if you store apples in a fridge then they stay fresh longer right. Then again this is testable to keep it keep it outside and check it if you keep the window curtains close then the ac would consume less electricity cool the room. Now it look like it is obvious, but it is obvious now because somebody has tested and shown that you know they tell you put the curtain on when you turn on the ac keep the door close, therefore it will consume less electricity because now you know that is how it works right.

So, that is hypothesis becomes you know help you to prove and become effective in day today living as per. So, now, you go to the second that is theory. So, what is theory?

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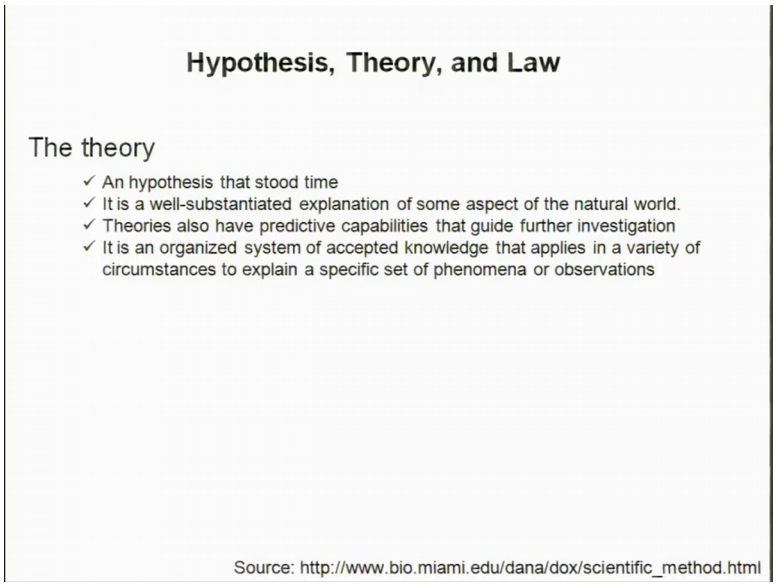

Hypothesis that stood time meaning at least nobody sure that the hypothesis wrong it may not be proven correct, but nobody has shown that it is not a good hypothesis it is well substantiated you know explanations. So, many others have also done work and then they are able to get data which again support a given a given hypothesis, therefore you know the hypothesis stayed for years.

For example, when you talk about Darwin contribution the theory of natural selection is not something that 1 can test it in the lab it is difficult right, but you know now we have. So, many different you know observations that account from multiple groups for over you know hundred years then now you know that you know this is theory a whatever hypothesis that you proposed is very attractive and still that is only explanation that we can give therefore, it becomes a theory.

It is an organized system accepted knowledge everybody was majority of the practicing scientist you know, they say that that is the best thing and it is fitting into whatever observation you get and this you know applies to in a variety of circumstance to explain a specific set of phenomena or observation. So, therefore, it becomes a theory. So, that is the theory but it is not proven yet, therefore it is not a law, but still you know hypothesis that is time tested by a number of group well accepted; therefore it becomes a theory like the theory of natural selection that something that I already told you.

Let us go to the third 1 that is called the law, what is law?

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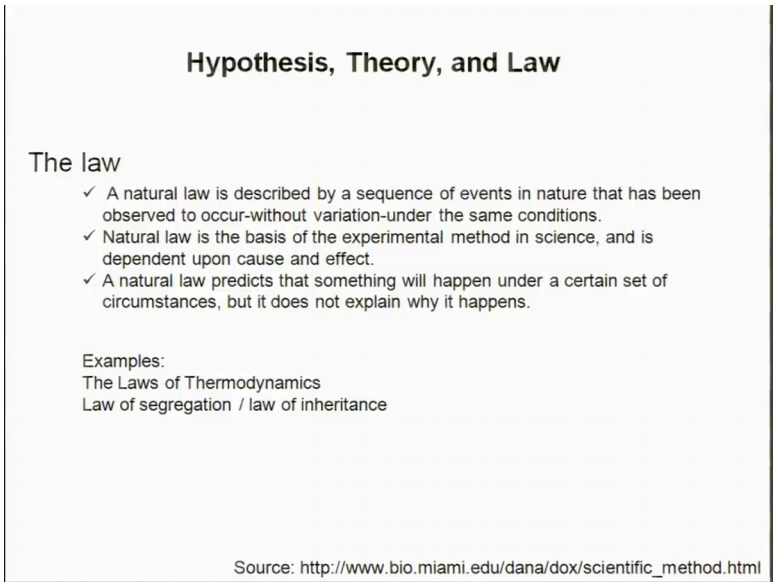

It is not about the law that governs our seek society it is is about the law that sort of explains as many other scientific phenomena, a natural law is destroyed by a sequence of events in natural that has been observed to occur without variation under the same conditions; when you have the experimental condition set then you repeat this experiment you know that this is what I am going to get over and over and again you can do this experimentally, you will get it and as expected you know hypothesis you will think products are as expected; therefore, it becomes a law natural law is a basis of experimental methods in science and is dependent upon cause and effect, so we can change the parameter to change.

So, then now we can say what are the parameters that regulate for examples you have enzyme you have substrate right, so there is a kinetics there is a law for it I am want to tell you because most of you know that. So, you know that if I increase the enzyme concentration what is the end effect right. So, you can do this that is what exactly explained in the law, when hypothesis becomes repeatable with the variation that you bring in and you expect this, what will happen and does happen then you know it becomes a law.

A natural law predicts that something will happen under certain set of circumstance, but you does not explain why it happens possible that it does not really explain why it happens, but it does explain that do happen the you call it as law the laws of

thermodynamics. Mendel law that we gave example all these are to begin with hypothesis, but time tested repeated tested by many now you know all the parameters you can predict and it will exact will happen given the parameters are correct; therefore, now you call it as a law because invariably that will happen if the conditions are right..

So, this is what it is you start with one or the other form of reasoning inductive, deductive then you have set of observations based on the observations you have an hypothesis, the hypothesis can be tested using experimental approach if you test and many other researchers test tested for multiple times various group different model different conditions and are able to get exactly as predicted by the hypothesis then it because of law.

But there could be certain hypothesis which cannot be testable or cannot be tested then, but still people do the experiments and that suggest that the hypothesis correct and then eventually the hypothesis over the time may become a theory tight still not proven, but that is the only way you can explain things; therefore, it is likely that is what is happening that is what is (Refer Time: 23:17) for both these you have hypothesis something tested found to be true that becomes law.

Something very convincing something, say that that is indeed the case, but you cannot prove it that becomes theory right. So, these are the 2 different you know ways by which you look into that. So, that is precisely the case that you have a deductive reasoning you have theory you have hypothesis.

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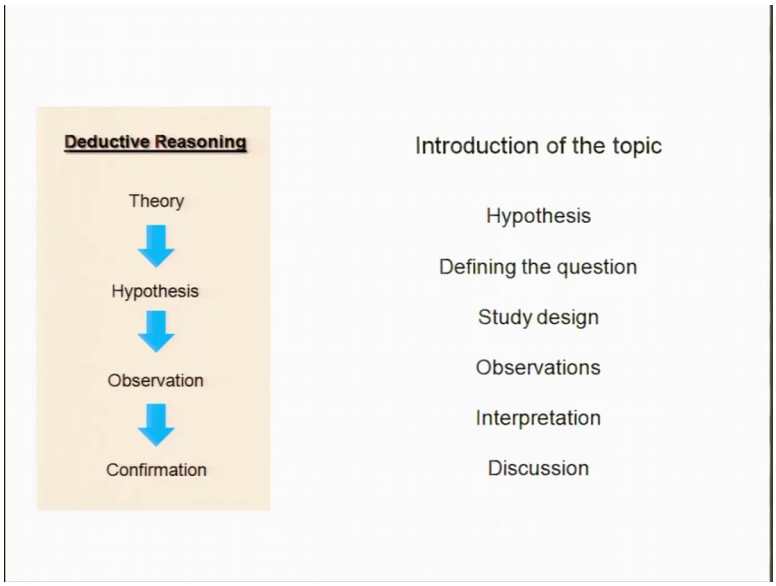

Then you do experiments and then you get observations and confirmation what is shown on the left side in the screen is the deductive reasoning. So, when you do this is what you report. So, when I come to scientific communication may be wondering why I am talking about all this things, because when you explain things you need to tell that this was my hypothesis and you have to say why your hypothesis could be correct reasoning right and then you have to tell how I tested my hypothesis and you have to tell what were your observations and then finally you have to conclude that your observation indeed prove that your hypothesis correct..

So, that is called as writing scientific writing if you write a paper or if you communicate like the way I do you present your you know ideas hypothesis and your observation that becomes oral communication then again it is called as communication.

So, this is how you introduce a topic that is shown on the right side, that you present your hypothesis based on certain assumptions observations and then you define the question because you may not test in you know the hypothesis in as a whole, but you may take certain elements and how do you test you come up with study design. So, you have certain models and that you have certain parameters and then that is what called as study design and you conduct experiments you have some observations and the observations based on that interpret something and then you extrapolate what is called as discussion. So, that is what called as communication.

Therefore you need to understand the philosophy behind science for you to really execute your experiments and then to convey or communicate to the audience. So, you need to understand the whole thing to be an effective communicator. So, I coming back to the original slide that I started with this in this week lecture.

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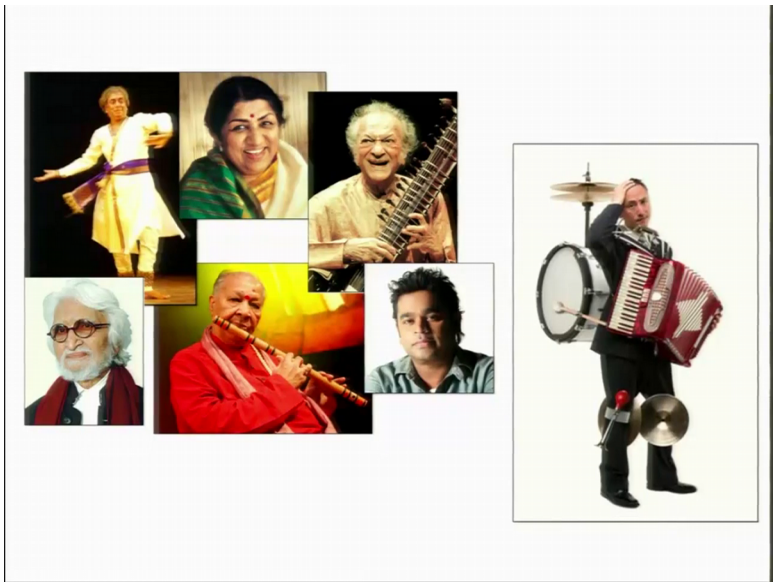

That you have performing artist some of them dance, some of them sing, some of them play music instruments some them do not do anything, but paint but some of them compose music right talk about AR Rahman, what he does he has to do many things he is a music composer what it does he basically listen to the story of the movie and he knows what are the characters when his particular song should be brought in..

So, you should know the context and then you express a particular mood whether it is a mood is something that you 2 people met they are very happy with each other, then you have a different kind of a mood or they are separating; for example, then it is a different mood or it is something else. So, you have to bring out the music to express the emotion. So, express the mood of that situation then you know you have to have that the you know composed, then you have to ask script then you have to ask the script writer to what the make the script such that it fits into the mood and then you have to have a singer who would you know sing..

So, beautifully to express the happiness or sorrow or whatever you know again it is depends on the context, then you have the orchestra the musicians who gel with the rest

other thing again conveying the same whatever particular information. So, that is what it does right. So, basically a music composer somebody uses so many other you know talents like a singer script writer you know musician and so on plus you have what is called the art director, you know who have this song being played and then you have all the characters background and sound you know music light you bring in and even there are visual effects to give add more strength to the you know whatever information that you would like to convey.

So, everything gels there to give you the feeling of whatever you know mood or saying that is there in a given movie and that is what the film is about, you know as a researcher you have to do the same thing like this you are the only 1 person; who have to do that you have to read get idea as to what has been done so far and then you have to develop an hypothesis develop methods, approaches, execute, carryout the experiments, document all the observations and study your observations right results extrapolate you know and then write communicate speak you have to do everything it is like this 1 man band.

A. R. Rahman, you are Lata Mangeshkar, you are Amitabh Bachchan and you are everyone you know. So, you have to do everything including being mf Husain because you have to make figures you have to make schematics to convey, what you want to convey in other words you are just like any other performing artist, if you want to communicate what you are done in addition to what you are done..

So, you have to learn all these people I am showing in the screen or someone who born with maybe limited talent, but with dedication they have the interest they have learnt the master and that did exceeding liver and you have to do something like that to excel in science as well it is a profession.

It is not a hobby because you know may be it is begin with as something like an hobby for all these artist why they become professional and that is exactly what you call in science as per to be an effective communicator you have to be a professional; you should know how to communicate for that you have to understood you should have understood what is science that is what I discuss. So, far I am going you know rest of the lecture I am going to really talk about what he really helps you to become an effective communicator.

I will give you some examples again. So, you need to know what is hypothesis you have define the questions.

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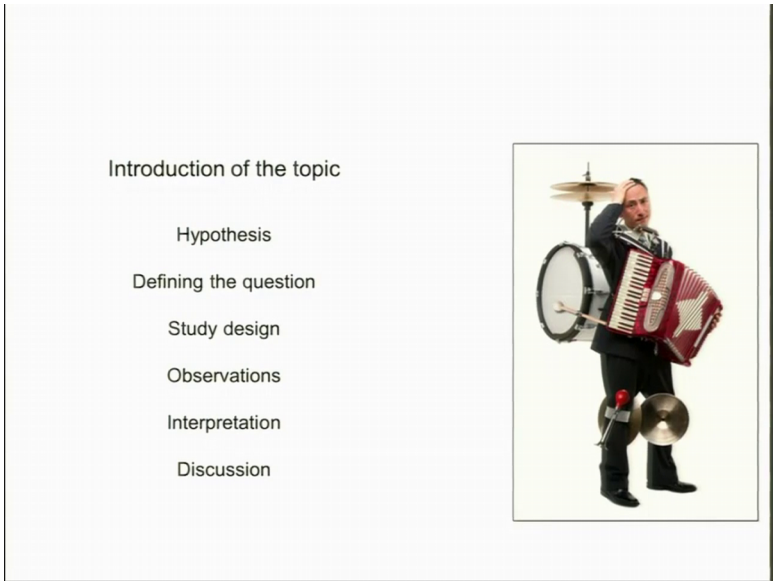

You know you have to address the questions by designing experiments, observe interpret discuss everything on your own you are a single man you know band whatever called as right. So, therefore, you have to do so you have to learn everything that is very very important and is important because you have to tell the story meaning what you observed; how good are your findings right these are very important if you do not communicate you will may have wonderful observations you know this science maybe path breaking, but unless you communicate others cannot understand they are not going to appreciate..

It is just like story telling you must have seen this movie PK you know it conveys at the end of the day when you move out of the movie hall you have a takeover message and that should be there whenever you communicate that oh my god this guy is done this and this is what is contribution, for that you have to have effective communication somehow is do exceptionally well because, the director putting lot of the word to convey what really had in his mind it is very challenging, you know you have to bring in characters, you have to give life to the characters, you have to think about the surrounding the dialogue the sound everything has to gel well to communicate, what you want to communicate. If you do not do well the movie will flop because audience do not like you

go you do not go again you tell others it is not what saying, but if the movie is good because you appreciated the story because it has been told so beautifully, because it carry something that you are connected with and you are able appreciate then you tell others go and watch the movie, so that is how it becomes box office hit.

So, therefore, is important that you communicate well in everyday including your science only then people would appreciate, it is not that a movie that did not you know hit the box office; the director was not really you know eager to do a better job he tried his best only thing he could not be the best. So, you have to be the best to communicate effectively as to what you have done, otherwise your research will not be appreciated you have examples again right there are movies that you know has huge investment.

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For example the one that is shown on the left side bahubali, you know it is a record movie in terms of the money spent in making a movie, because the story required that kind of settings to effectively communicate a story you ok. Now, therefore, you need all this thing to you know tell that story therefore, the invested and it was so successful because, they are able to communicate what they wish to and people appreciated.

Therefore, there was a revenue generation as per and the right side you have another movie which is a low budget movie nothing there were 3 characters of course, character 1 in how a car that is all the movie was about nothing is there, but still the story was so effective right. So, it is not that how much we invest that makes a story successful or not

a movie successful or not. But how good you are able to communicate how good you are able to tell the story it is exactly the same thing in science as per your research, may involve lot of you know fancy equipments lot of money grant whatever it is.

But still you are unable to communicate it may not really sell well or he may have a simple question which did not require any sophistical equipment, remember susumu ohnos you know discoveries just you know making chromosome cutting the chromosome weighing it, but still you could come up with discoveries that became laws right like.

For example there was a paper that came in nature from India which talked about, how the Indian population evolved you know it involve sequencing of you know multiple genes huge you know experimental setup, lot of funding to come up with certain discovery it will very very fascinating. You could also have discoveries coming out in the very similar journal, but which had very little you know input in terms of money very simple equipment still we can make you know good story..

So, it all about how you conceive ideas and then how do you come up with questions that are original question that are significant, how do you test the hypothesis what observation that you have and finally, how good you are able to communicate, because you have to tell the editor that your discoveries are worth to be published in high impact journal therefore, they can read they can understand. If you do not tell the story well they are like you when you go to a movie you do not like a movie or going to say forget about you do not go the same thing editor will say it is worthless reject, he does not go for review therefore, you should be able to communicate well.

And this course is nothing, but about making you understand some of the aspects as to how you can make an effective communication and that is what called as the science of communication; we are coming back to the old you know slide to tell that scientific communication it is exceedingly important and from the next week onwards we are going to take examples and you are going to discuss as to how you can communicate better, with that we will end the first week and we will see in the next week.