Nature to Nano- an interactive graphic book to learn Biomimicry

Guided by
Neelakantan

GARIMA

A Thesis Submitted to

Indian Institute of Technology Hyderabad

In Partial Fulfillment of the Requirements for

The Degree of Master of Design

Department of Design

July 2016

Declaration

I declare that this written submission represents my ideas in my own words, and where ideas or words of others have been included; I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission.
I understand that any violation of the above will be a cause for disciplinary action by the Institute and can also evoke penal action from the sources that have thus not been properly cited, or from whom proper permission has not been taken when needed.

(Signature)

GARIMA

MD14MDES11003

Approval Sheet

This thesis entitled "Nature to Nano- an interactive graphic book to learn Biomimcry" by Garima is approved for the degree of Master of Design from IIT Hyderabad.

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Furthermore I would like to thank Dr Deepak.J Mathew for giving me this opportunity as well for the support on the way. Also, I like to thank Dr Prasad Onkar, who has willingly shared his precious thoughts during the process. I thank to Delwyn sir for giving direction when I got stuck in middle of the project..With many thanks to Farooq Imran Khan, who guided me as technical consultant and supported me throughout entire process.

Abstract

A picture is worth than a thousand words and when the subject is a combination of art and science this quote seems more worthy and relatable. Science and art naturally overlaps. Both are a means of investigation and follows nature. Both Artist and scientist study materials, people, culture, history, religion, mythology in their own method and learn to transform information into something more accessible. This is the combination of delicate beauty and technical accuracy. In other words, Aesthetic and logic collides to perform something more engaging and a different experience of learning.

This thesis addresses the concept of learning through visuals, a method which help student in better understanding of subject, encourages towards reading and help in developing critical thinking skills.

It is a collaborative project of two departments in IIT Hyderabad which are Department of Design, Department of Metallurgy and material engineering and TLC . In which the objective was to understand the complex nano concepts of nature and its science transforming into easy and understandable visuals for teenage students.

The main aim is to develop an interactive visual book targeted 15+ years young minds to inspire them to look at the nature and learn the complex concepts and principles for material design from nature for superior performance. This book involves the intricate and complicated concepts of nano structure, Hierarchical organization, Mimicking the nature, wet ability structural color, super adhesion anti reflection, mechanical strength, Van der waal force, Protein arrangement etc. Designed to appeal visual learners, reluctant readers and anyone who is keen interested to know more about the science and world of nano.

This an attempts of bringing interest in the subject through narration and visual representation of the concepts with proper scalable examples that brings a wow factor and leaves the student with a curiosity of all the possible things

that can be explored and achieved in this domain. As a designer my approach was to understand the content from scratch and tried to illustrate different styles to give the precise feel of nature in all different examples. This thesis is my journey of learning a totally new subject, understanding the concepts, developing them into easy and clear illustration.

About TLC

India has been home to the oldest universities of the world, where different modes of teaching were employed in diverse areas of study. However, teaching methods have not kept pace with the revolutionary changes in various disciplines and the aspirations of today's generation. IIT Hyderabad, since its inception, has identified this gap and made several attempts to bridge it.

These efforts have materialized into a flexible and robust academic program, known as the Fractal Academic Program at IIT Hyderabad. This program has induced several changes in pedagogy and spawned novel teaching styles that have managed to engage student interest. In order to share its experiences with teachers in various institutions across the country for effective student-teacher interaction, IIT Hyderabad has established a Teaching Learning Centre under the Pandit Madan Mohan Malviya National Mission, MHRD.

Project Requirement and Target audience

The objective of the project was to prepare an interactive book targeted at 15+ year's young minds to inspire them to look at the nature and learn the engineering design, process and principles for materials design from nature for superior performance.

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Project Proposal

Introduction

The project aims to design Educative Visual storybook for the subject called Material science taught in Metallurgy and material science engineering, which can help in developing curiosity towards the subject or excite students to get deeply engage with subject.
"Materials Science involves the study of the relationships between the synthesis, processing, structure, properties, and performance of materials that enable an engineering function".
In which is Bio inspired or Bio mimicry terms are going to be focused.
In Bio Inspiration we take inspiration from the nature and then use our scientific tools to create similar kind of structure and similar application, what nature has provided.
In Bio mimicry, we just take the natural template and try to replicate their properties in materials."Biomimicry is an approach to innovation that seeks sustainable solutions to human challenges by emulating nature's time-tested patterns and strategies."

Objective

The project aims at bridging these gaps by bringing interest in the subject by storytelling and visual representation of the concepts with proper scalable examples that brings a wow factor and leaves the student with a curiosity of all the possible things that can be explored and achieved in this domain.

Problem Statement

The course that the students cover is too theoretical and not able to engage further more application. Memorizing such huge content becomes very painful and in the process the concepts take a backseat. It is more important to understand the concept rather than numeric values especially in the Nano world where everything is so small that nobody can realize it in their normal routine. The concepts of bio inspiration and Bio mimicry are hence more important than the value and units in which they are evaluated. For instance, a

student might be able to memorize or remember 2 nanometer but it becomes hard for him to understand how much length 2 nanometer would be. These are the scenarios which call for real life scalable examples or analogies that can help students relate it more practically. In addition to this the course structure of material science can get a bit overloading without proper concepts and interest.

Scope

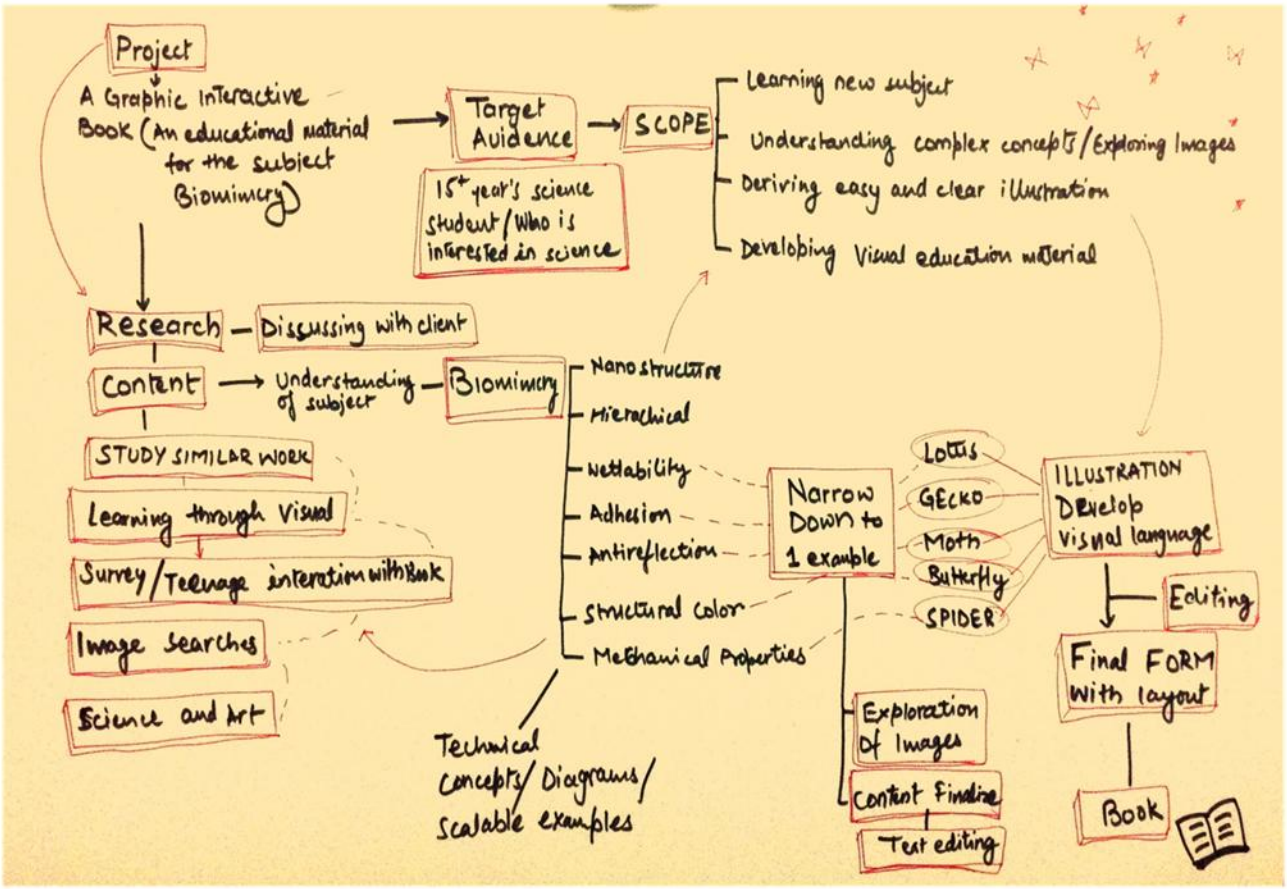
During this project I hope to learn about Biomimicy, how human are getting inspired by nature and developing product to solve daily problem. There is a wow factor in this subject because nature inspiration is around us, it just we need to observe things. I wish to simplify those complex terms and to develop easy and simple illustration and try to develop proper book by bringing typography and illustration into the picture.

Process

- Process will include collection of data (content and images)
- Understanding the content
- Analysis content and looking up for suitable images
- Studying the similar work and digging down the books
- Understand the teenage interaction with books by taking survey/ one on one interview.
- Exploring Images and Illustration
- Narrowing down the content and finalizing illustration accordingly
- Design development/ style decision making
- Execution of design

Process

Project is broken down in several steps to be followed during the project. Mind mapping helped in deciding the content.



An approach towards the project

(Understanding the Importance of Visuals in Education)

Visual thinking and learning utilize graphical ways of working with ideas and presenting information. Research in both educational theory and cognitive psychology tells us that visual learning is among the very best methods for teaching students of all ages how to think and how to learn.

Visually learning where the learner better understands and retains information when ideas, words and concepts are associated with images. Research tells us that the majority of students in a regular classroom need to see information in order to learn it. Some common visual learning strategies include creating graphic organizers, diagramming, mind mapping, outlining and more.

Pictures help students in many ways:

It introduces children to the concept of reading, even if they can't read.

It helps students integrate new knowledge, According to research, students better remember information when it is represented and learned both visually and verbally.

It encourages discussion and debate among young and the older and helps in understanding the concept better.

It helps in strengthens visual thinking skill which is good because understanding through image in mind give a clear idea of any complex problem.

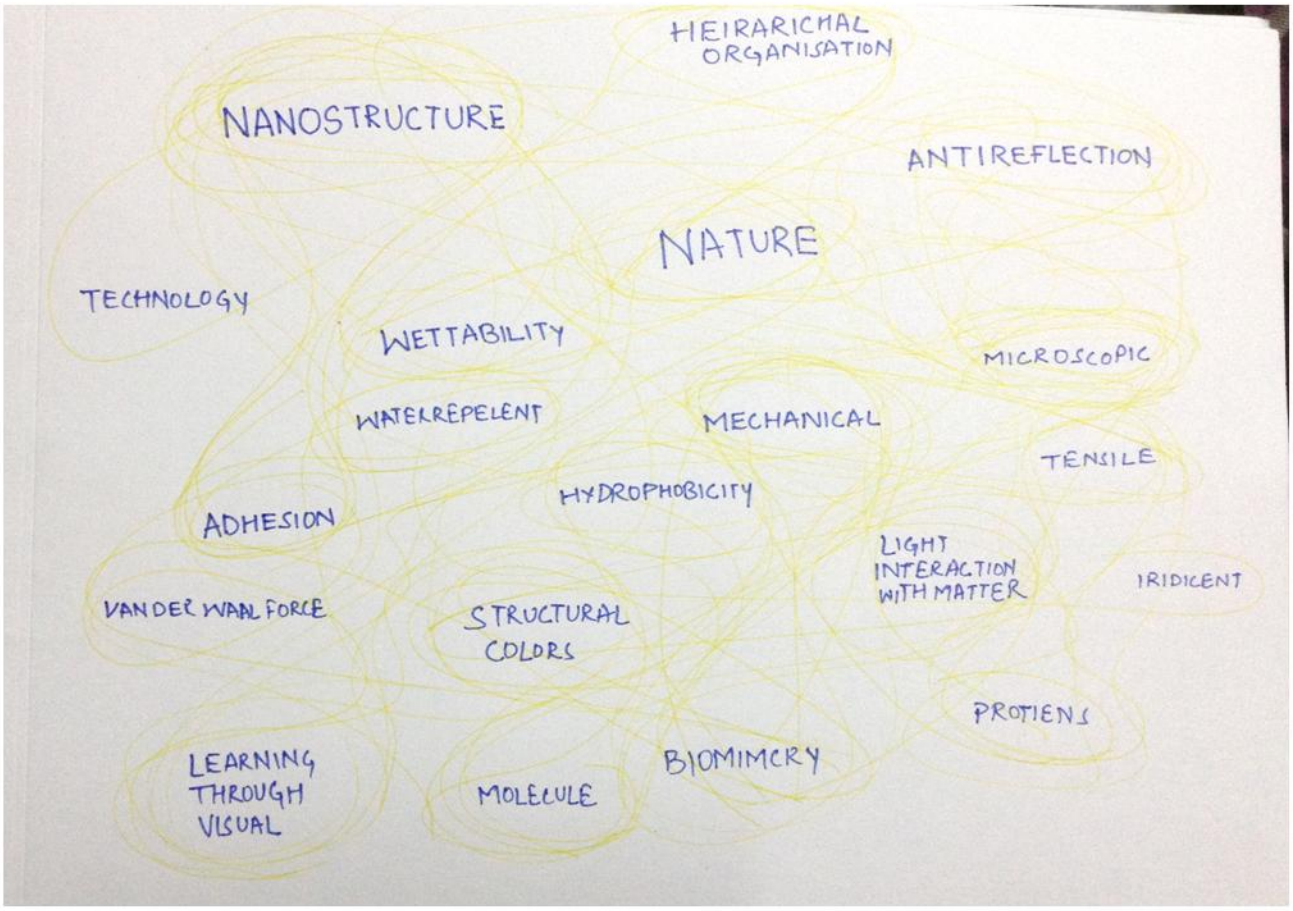
It helps in developing critical thinking skills, according to Karen Lotz of Candlewick Press points out in a New York Times piece: "To some degree, picture books force an analog way of thinking. From picture to picture, as the reader interacts with the book, their imagination is filling in

the missing themes. Also J. Richard Gentry in Psychology Today says "Picture books stimulate a state of mind in children that words alone can't achieve.

Chapter 1
Research

Understanding the content

The first phase of the project happens to be the most time consuming and the most reinforcing as it necessitate me to dive into books and videos.
The content of project had an unassuming beginning so in order to understand the subject I used to meet my co-guides (engineering), where they shared their thoughts, explained me theories, terms, concepts because this subject was totally new to me. I dig up into the most influential videos, reading articles and book.
My methodology was broken into different steps keeping the project objective in mind. Initial research was all around the Biomimcry subject. After getting know something about the content, I looked for hoe visuals would help in learning the subject, I studied about the Visual learning and how science and art work together. I also started searching similar kind of work done in this field in order to get inspiration.
I was more involved immersing myself into fundamentals theories of physics, nano technology, chemistry through videos and books.
Meanwhile I kept sketching alongside and started collecting relevant images for reference and inspiration. I also took survey to understand the interaction of book among the students especially when it is a visual book.


HEIRARICHAL ORGANISATION
NANOSTRUCTURE
ANTIREFLECTION
NATURE
TECHNOLOGY
WETTABILITY
MICROSCOPIC
WATERREPELENT
MECHANICAL
TENSILE
HYDROPHOBICITY
ADHESION
LIGHT INTERACTION WITH MATTER
IRIDICENT
VAN DER WAAL FORCE
STRUCTURAL COLORS
PROTIENS
LEARNING THROUGH VISUAL
BIOMIMCRY
MOLECULE

Biomimicry

Nature has developed materials, objects and process that function from the macro scale to the nanoscale. It started with Leonardo da vinci, (fig 1) when he observed the anatomy and the flying system of birds and filled with so many notebooks with them. The emerging field of biomimetics allows one to mimic biology or nature to develop nano materials and processes. A great number of have been investigated in order to get inspired by the nature.

According to Janine M. Benyus author of book called Biomimicry Innovation inspired by nature, explains biomimicry in three components:

Nature as model Biomimicry is a new science that studies Nature's models and then imitates or takes inspiration from these designs and processes to solve human problems.

Nature as measure Biomimicry uses an ecological standard to judge "rightness" of our innovations.

Nature as mentor Biomimicry is a new way of viewing and valuing Nature.

Definition

Biologically inspired design or adaptation or derivation from nature is referred to as biomimetics. It means mimicking nature. It is derived from the greek word biomimesis coined by polymath Otto Schmitt in 1957. It involves understanding of biological functions, structures and principles of various objects found in nature and designed to various materials.

The beautiful iridescent colours of the butterfly, the creepy house lizard ambling on the walls, the clean lotus leaf in the mud, the strong spider silk forming the web, the colour changing chameleon, biomimicry is a vast subject itself so we decided to go further with the five selected properties including nanostructure, hierarchical organisation SEM, protein and molecule. For understanding these properties, we narrowed down the content with having one example each. The five properties are as follows:

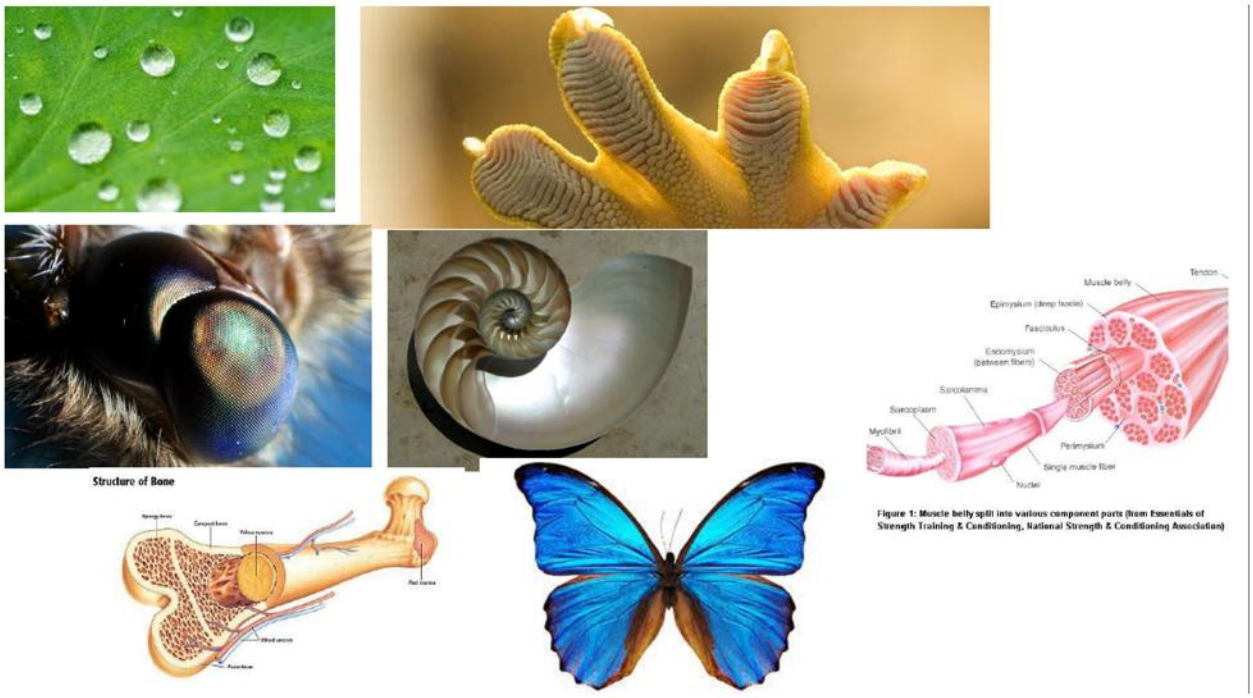


Figure 1: Muscle belly split into various component parts (from Essentials of Strength Training & Conditioning, National Strength & Conditioning Association)

Wettability refers to the study of how a liquid deposited on a solid (or liquid) substrate spreads out. It determines how fast a liquid (such as water or a solvent) will seep through the dust.

Lotus: Lotus has this quality that water drops falling onto the leaves can bead up and roll off, with washing dirt from the lotus leaves so that they are self-cleaning, which is known as "Lotus effect". This function is called as hydrophobicity

Adhesion is the process or condition of sticking or staying attached.

Gecko : The toes of a gecko are divided into nanoscale hair-like structures. When a gecko places its foot on the wall and curls its toes, these nanoscale structures interact with the wall on the atomic level. The forces (van-der-waals forces) between the nano-structured hairs of the gecko foot and the atoms of the wall are strong enough to hold up the gecko. Scientists are working to make materials that use gecko-like nano-structures for adhesion.

Antireflection purpose is to reduce the reflection off from the lens.

Moth eyes have a remarkable anti-reflective ability that is vital to their sight abilities in nocturnal activity. For them it is important not to reflect the light,

since the reflection makes vulnerable to predators. The eyes of moths consist of hundreds of hexagonally organized nanoscopic pillars, each approximately 200 nm in diameter and height, which result in a very low reflectance for visible light. These nanostructures' optical surfaces make the eye surface nearly antireflective in any direction.

Structural color is created by an optical effect (such as interference, refraction, or diffraction) rather than by a pigment. They arise from the arrangement of physical structures interacting with light to produce a particular color.

Morpho Butterfly of blue morpho's wings look blue, but they aren't actually colored blue. The iridescent blue coloring is a result of the microscopic scales on the backs of their wings, which reflect light. The structure of the scales is tetrahedral (pyramid-shaped), and they reflect light. The colors vary depending on the angle.

Mechanical properties are the most common properties considered for strength, ductility, hardness, impact resistance, and fracture toughness. Most structural materials are anisotropic, which means that their material properties vary with orientation.

Spider silk have tensile strengths comparable to steel and some silks are nearly as elastic as rubber on a weight to weight basis. In combining these two properties, silks reveal a toughness that is two to three times that of synthetic fibers like Nylon or Kevlar. Spider silk is also antimicrobial, hypoallergenic and completely biodegradable. Taking inspiration from spider silk scientist are developing products.

Learning through visual

Pastor Chuck -"You take something that is familiar to them, something that they can understand, and you tell the story, and then by the story you illustrate the truth that you are trying to get across to them."

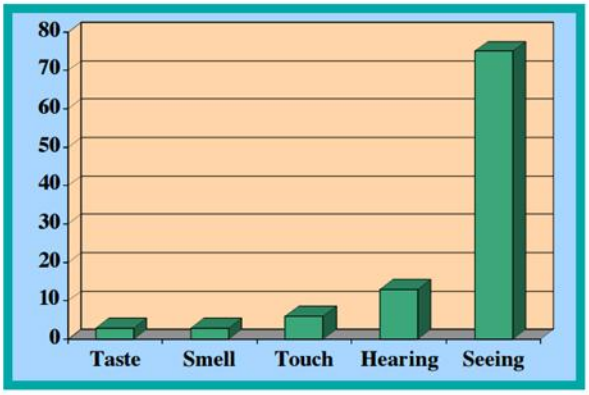
Research indicates that visual cues help us to better retrieve and remember information. The research outcomes on visual learning make complete sense when consider that our brain is mainly an image processor (much of our sensory cortex is devoted to vision), not a word processor. In fact, the part of the brain used to process words is quite small in comparison to the part that processes visual images. Words are abstract and rather difficult for the brain to retain, whereas visuals are concrete and, as such, more easily remembered.

There are many ways visual help students in learning

Visual learning helps students clarify their thoughts
Students see how ideas are connected and realise how information can be grouped and organised. With visual learning, new concepts are more thoroughly and easily understood when they are linked to prior knowledge.

Visual learning helps students organise and analyse information
Students can use diagrams and plots to display large amounts of information in ways that are easy to understand and help reveal relationships and patterns.
Visual learning helps students integrate new knowledge
According to research, students better remember information when it is represented and learned both visually and verbally.

Visuals Clarify the Material Being Taught In normal day-to-day living we learn: 3% through taste 3% through smell 6% through touch 13% through hearing 75% through seeing.



Biomimicry is a subject that lies in nanostructure which is like invisible to visible. So giving a visual approach could make the subject better understandable.

Survey

Please enter your name?
[Yogesh Pandey]

Class and Subject
[Btech-Mechanical Engineering]

1. Do you know about bio inspired technology or bio
[No]

2. What are the technology or concepts that you have
about bio mimicry?
[I haven''t come across biomimicry.]

3. What are your methods to understand difficult conc
and better way? 15-20 words
[By listening and reading]

4. Do you watch any science channel? For example
Animal planet.
[Yes]

5. What is your favorite show on the channel and
words
[Discovery channel,because I like the episodes o

6. What is the best part you like about the sho
[Survival]

7. What is your favorite informative book and w
[Stay hungry stay foolish]

8. a.Think of a characteristics/quality in any
would like to possess. Name it.
[Ant...because of their perseverance]

b. If you had that power with you, how would y
regular life? 15-20 words

Please enter your name?
[Deeksha Verma]

Class and Subject
[BFA 1st year]

1. Do you know about bio inspired technology or biomimicry?
[No]

2. What are the technology or concepts that you have come across
about bio mimicry?
[I dnt knw anythng abt it]

3. What are your methods to understand difficult concepts in easy
and better way? 15-20 words
[Read it 2-3 times n repeat it by speaking evrything loud n
clear]

4. Do you watch any science channel? For example Discovery or
Animal planet.
[Yes]

5. What is your favorite show on the channel and why? 15- 20
words
[Man v/s wild is my fvrt I lov d adventure in it n techniques
they made us learn]

6. What is the best part you like about the show?
[Adventure]

7. What is your favorite informative book and why? 15-20 words

8. a.Think of a characteristics/quality in any animal which you
would like to possess. Name it.
[Pigeon...i wanna fly high like a pigeon]

b. Y
power with you, how would you

[Victor Saha]

Class and Subject
[12th]

know about bio inspired technology or bi

e the technology or concepts that you have
mimicry?
b glass.]

e your methods to understand difficult concep
way? 15-20 words
late theme with surrounding or giving it a fu

watch any science channel? For example Dis
net.
Geographic channel]

your favorite show on the channel and why?
stupid because it shows how science is impor
nt of life.]

the best part you like about the show?
os.]

your favorite informative book and why? 15-20
The author of this book is an Internet cartoonist
safety expert. He likes it when things catch fi
hich means he does not have your best interest
publisher and the author disclaim responsibility
effects resulting, directly or indirect
contained in this book.""

Please enter your name?
[Zaiba Jahan]

Class and Subject
[12 stream science]

1. Do you know about bio inspired technology or biomimicry?
[Yes,it is the imination of models,system and elements of nature
for the solving complex human problems.]

2. What are the technology o
about bio mimicry?
[It create products,processes
helpful to a new ways of livi
earth.]

3. What are your methods to u
and better way? 15-20 words
[My mathod is very simple.Firs
the particular concept and try
language.]

4. Do you watch any science ch
Animal planet.
[Yes.I do]

5. What is your favorite show o
words
[My favorite show is ""Man Vs w
how to survive.]

6. What is the best part you lik
[I like most when Baer Grills ea
show.]

7. What is your favorite informat
[My favorite informative book is

Please enter your name?
[Anjali Sharma]

Class and Subject
[12th , PCB]

1. Do you know about bio inspired technology or biomimicry?
[Yes ,I''ve recently heard about it in a career counseling
session.]

2. What are the technology or concepts that you have come across
about bio mimicry?
[It is the imitation of elements of nature for the purpose of
solving common and complex human problems.]

3. What are your methods to understand difficult concepts in easy
and better way? 15-20 words
[By writing and sometimes use of audio visuals of the related
topic.]

4. Do you watch any science channel? For example Discovery or
Animal planet.
[National geographic and Discovery.]

5. What is your favorite show on the channel and why? 15- 20
words
[Science of stupid and You have been warned.]

6. What is the best part you like about the show?
[It is an entertaining and knowledgeable programme.]

7. What is your favorite informative book and why? 15-20 words
[Tell me why]

8. a.Think of a characteristics/quality in any animal which you
possess. Name it.

Please enter your name?
[Bipul Swargiary]

and Subject

you know about bio inspired technology or biomimicry?
read some articles on it.]

t are the technology or concepts that you have come across
bio mimicry?
ation, display technology, pharmaceutical technology which
mimicry of virus etc.]

are your methods to understand difficult concepts in easy
er way? 15-20 words
about the same topic again and again from different
d watch video.]

watch any science channel? For example Discovery or
net.
etimes like Discovery n nat geo]

your favorite show on the channel and why? 15- 20

n how do they do it, because it exercise my brain to

e best part you like about the show?
cts n truth n info that i didnt knw especially about
technology affects us]

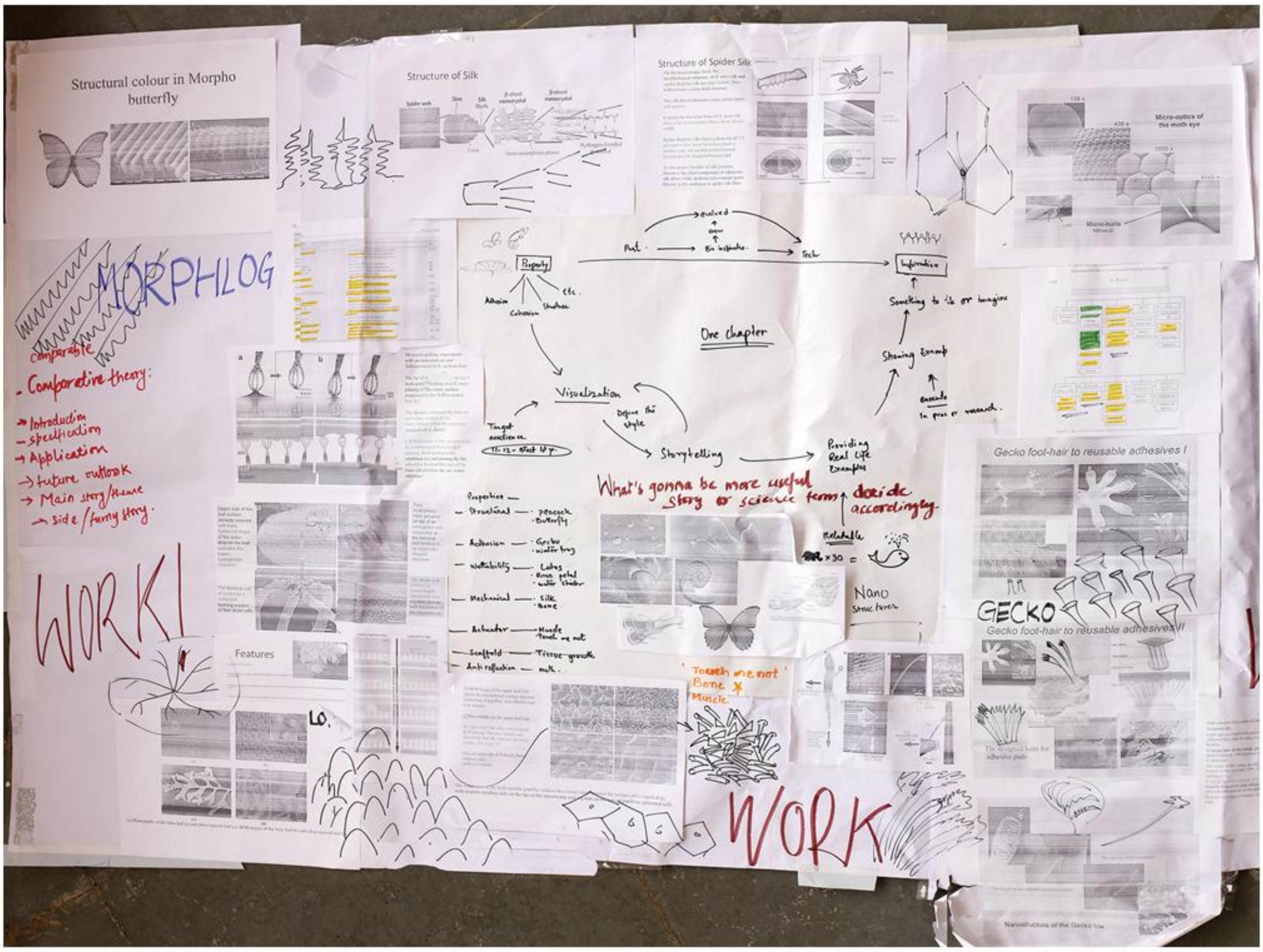
r favorite informative book and why? 15-20 words
ny favourite book but i personally like books
about human body and nature.]

characteristics/quality in any animal which you

I performed an online survey as well as one on one interviews with 15 students who were in class 9-10-11-12th, In order to understand their interaction with books, how they manage to learn complex terms, their methods to understand subject.

I observed number of anomalies in which firstly, when they get to know new

terms or concepts, most of them start looking up relevant videos, Images, diagram, other medium of visuals.
Secondly, they were interested in more concrete, real and direct information rather than that conventional and fictitious way of story based visuals.
For instance, A student (interviewee) loves watching sciency shows on science channels (Discovery, Animal planet, Geographic etc) because it gives him a real and direct information with to the point narration that enthusiast him to get more involve and make something similar.


Structural colour in Morpho butterfly
Structure of Silk
Structure of Spider Silk
Micro-optics of the moth eye
MORPHLOG
comparable
- Comparative theory:
→ Introduction
- specification
→ Application
→ future outlook
→ Main story/theme
→ side/funny story
WORK!
One chapter
Property
Visualization
Storytelling
Providing Real Life Examples
What's gonna be more useful story or science term decide accordingly.
Gecko foot-hair to reusable adhesives I
GECKO
Gecko foot-hair to reusable adhesives II
Features
Nano structures
Properties
Structural — Peacock, Butterfly
Adhesion — Gecko
Wettability — Lotus
Mechanical — Silk, Bone
Actuator — Muscle
Scaffold — Tissue growth
Anti-reflection — Moth
Teeth are not Bone X Muscle
WORK
Nanostructure of the Gecko toe

Source of information and Book reviews

I review books and similar project to understand how project works and followed images for inspiration.
I gained new insights and deepens my understanding of the way the world works from a scientific perspective when they engage with science people. Both my Guides and I were exposed to new information and a broader way of doing things.

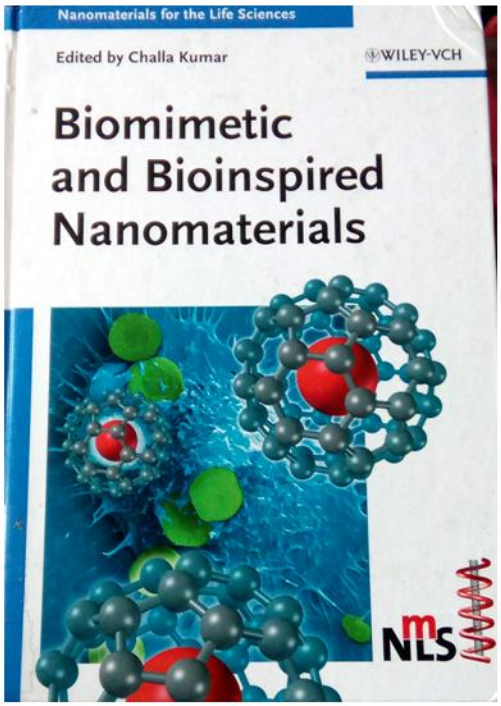
I selectively collected a list of relevant information available in books and videos. Meanwhile I kept sketching alongside; I found that there are different ways of visuals that are showing same information.

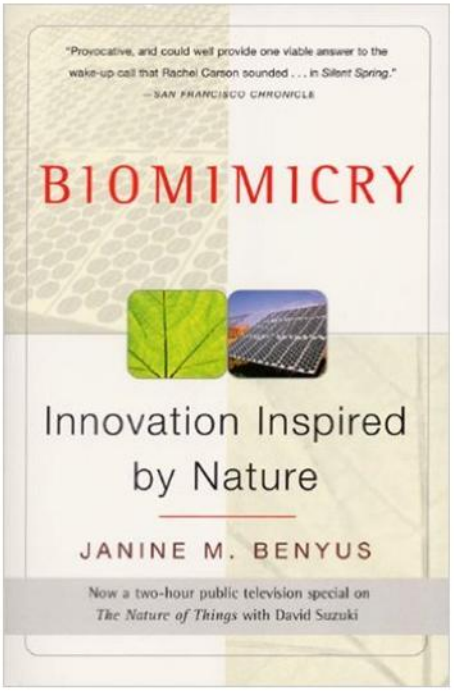
Ted Ed videos are Ted's youth and educative videos, growing library of original animated videos to help curious minds around the world. These animated videos create engagement and explains complex but clear information.

Smart materials: This show is a series on materials inspired by nature in which narrator explores the idea behind some of the famous inventions on biomimicry. This show covers:
The wonders of nature on nano level and how scientists are taking inspiration.
The process by which that special function take place.
Application for daily life problems
Creating an another level of world where everything is natural.

Books

This book written by Challa kumar contributes in-depth knowledge about the content of the project. From technical to factual information it explains how nano worlds are an inspiration for human kind.

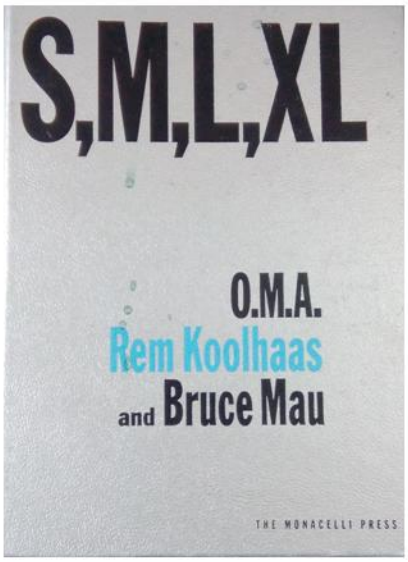


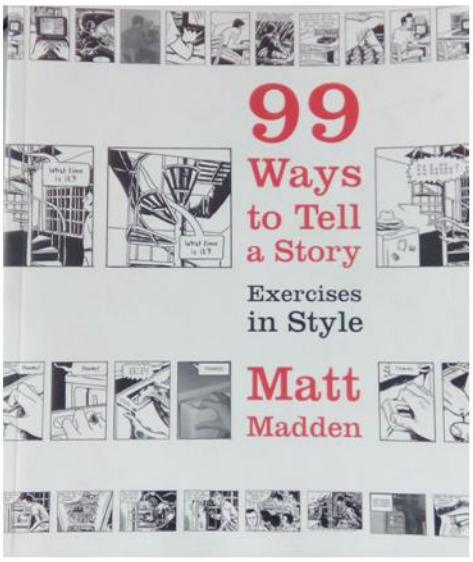


Biomimicry this book written by Janine M Benyus, explains how science is studying nature's best ideas to solve toughest problems. She shares nature's design and biomimicry in action.

Other books

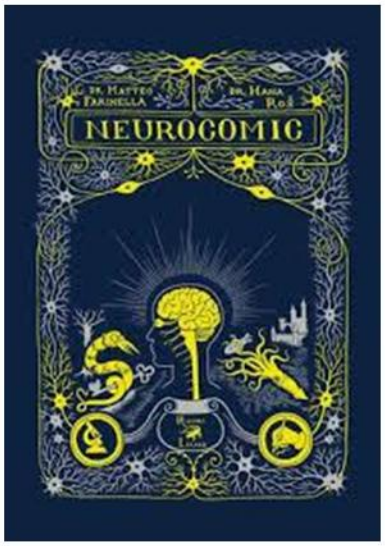
SMLXL by Rem Koolhaas and Bruce Mau It's a altogether a different kind of book or collection of stories, articles, comics, news , essays compiled in one. Breaking the regular norm of book writing helped me in putting my project in one place.





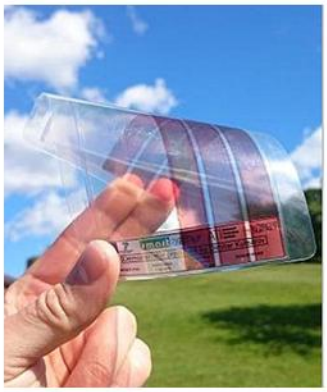
99 Ways to Tell a Story: Exercises in Style by Matt madden It's an interesting experimental graphic novel showed one story in 99 ways.

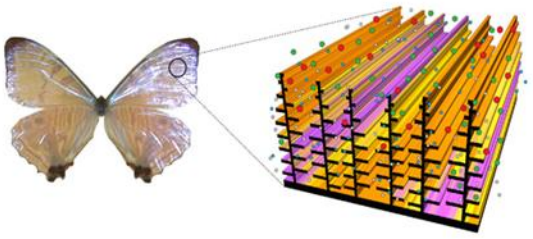
Neurocomic Hana Ro and Matteo Farinella is a graphic novel on how brain works with nice black and white illustration. It has explained through morphology method.
"Neurocomic" is a journey through the human brain: a place of neuron forests, memory caves, and castles of deception. Along the way, you'll encounter Boschean beasts, giant squid, guitar-playing sea slugs, and the great pioneers of neuroscience.

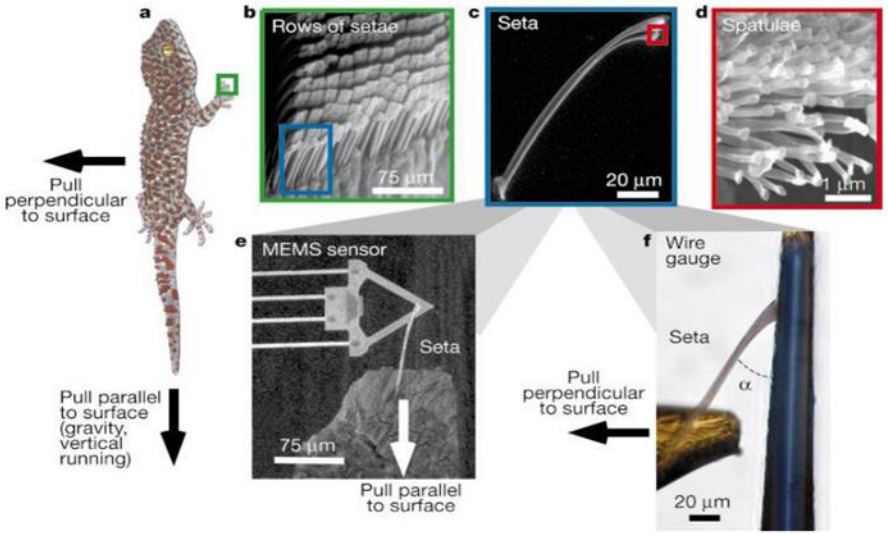


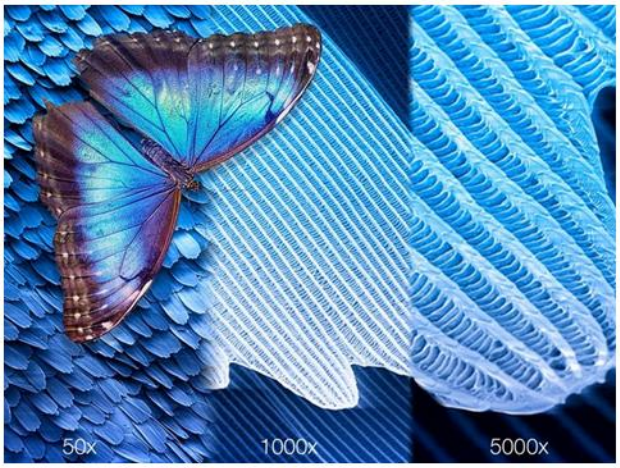
Images

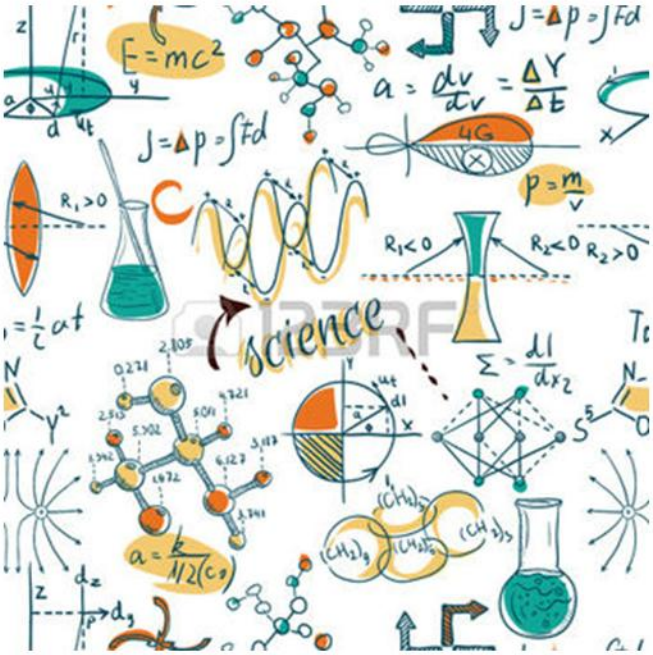
I collected a bucket of images for reference



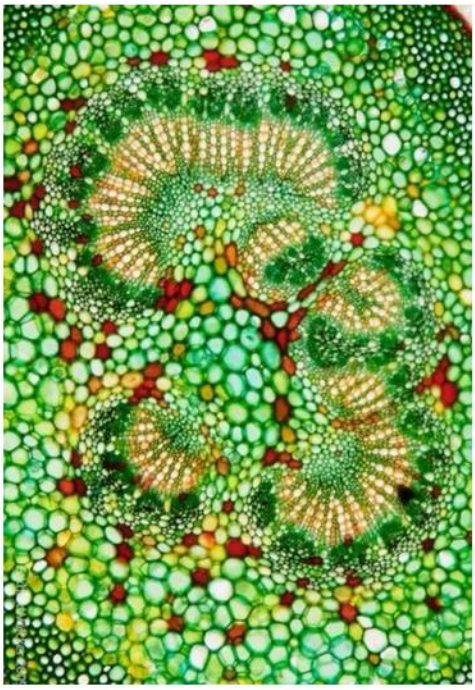


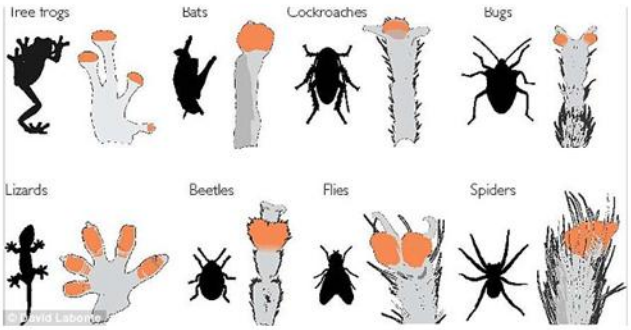


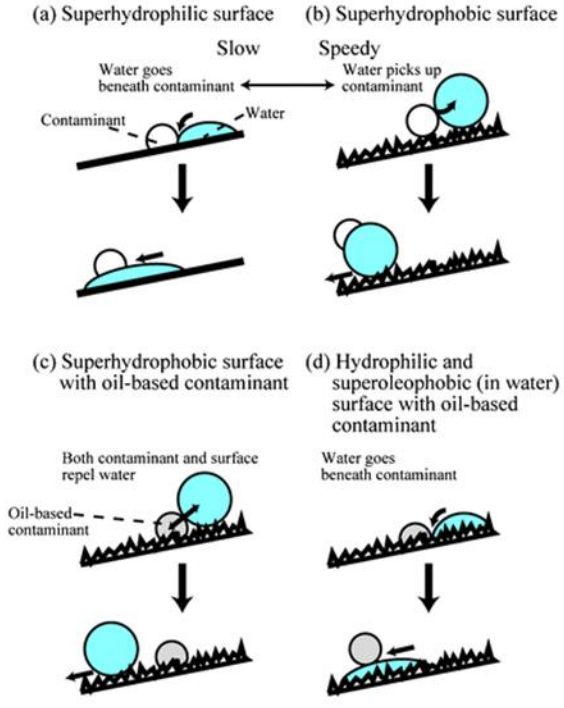


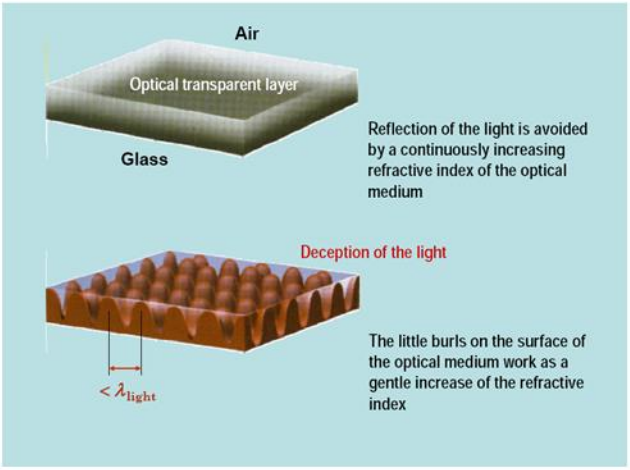


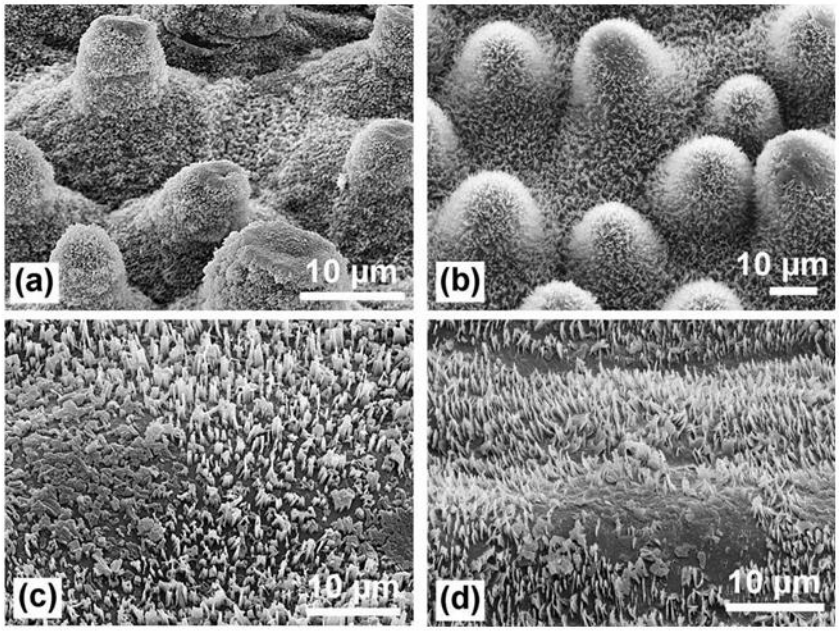

San Marco
FLORIAN

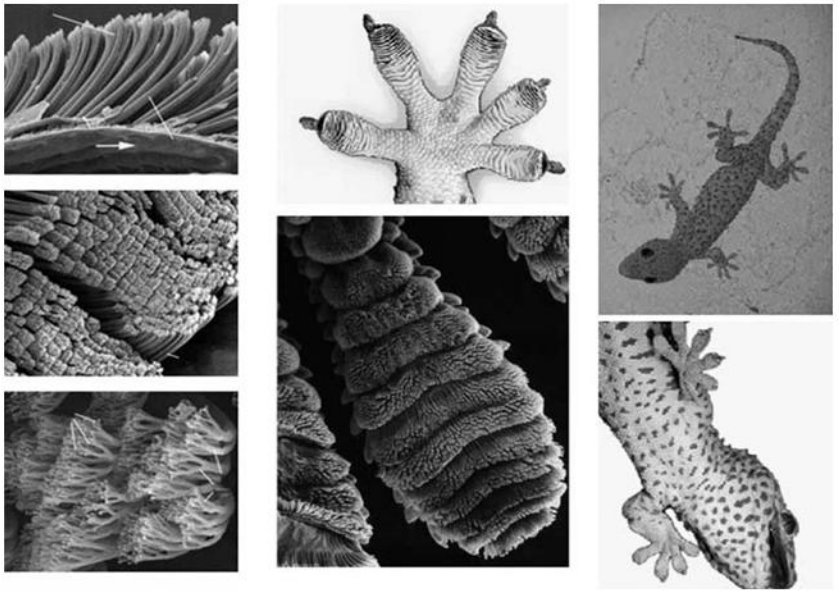


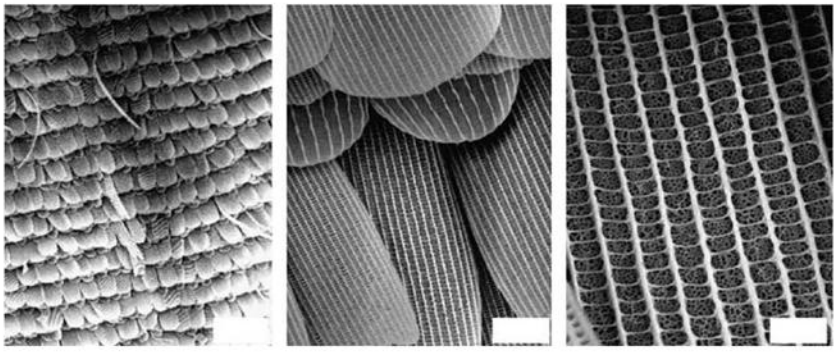

Tree frogs
Bats
Cockroaches
Bugs
Lizards
Beetles
Flies
Spiders


(a) Superhydrophilic surface
(b) Superhydrophobic surface
Slow
Speedy
Water goes beneath contaminant
Water picks up contaminant
Contaminant
Water
(c) Superhydrophobic surface with oil-based contaminant
(d) Hydrophilic and superoleophobic (in water) surface with oil-based contaminant
Both contaminant and surface repel water
Oil-based contaminant
Water goes beneath contaminant


Air
Optical transparent layer
Glass
Reflection of the light is avoided by a continuously increasing refractive index of the optical medium
Deception of the light
$< \lambda_{light}$
The little burls on the surface of the optical medium work as a gentle increase of the refractive index


(a)
10 μm
(b)
10 μm
(c)
10 μm
(d)
10 μm





Chapter 2
Visual intervention

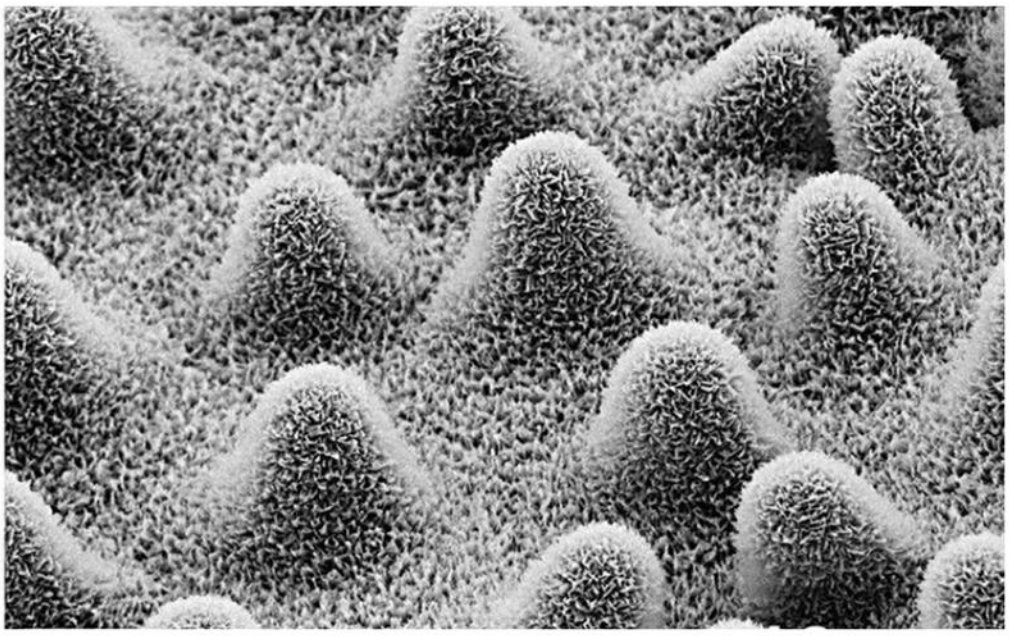
Chapter 2
Visual intervention

Part two finally brought in visuals to the project as it involved investigation of concepts, images and diagrams. Breaking them down into steps, playing with forms and mixing humor.
After understanding enough I started exploring drawing with different styles and methods. Brainstorming, storyboarding, discussion helped me a lot in making illustration.
I kept in mind the twelve major principles of design being line, shape and form, space, texture, value, color, repetition, variety, rhythm, balance, emphasis, etc combined to create the strategy of the visual aesthetic that works to compliment the technical terms/concepts of biomimicry.

I studied how meaning is manifested in visual images by following the pictures of two titans of natural history, Linnaeus and Buffon, present excellent case in their philosophies. Linnaeus's organizing principle called for clear, precise, explicit and comprehensive drawings, often composed in flat, spare, and grid-like patterns devoid of any reference to environment. The images used by Buffon dwell less on the physical attributes of animals and more on portraying the habitat and habits of animals. His subjects are animated, dynamic, and integrated into the landscape.

Illustration Process

I begin by thoroughly studying the subject. Observation has done through photographs. In order to capture details I studied b/w SEM images to create colorful illustration of nanoscale . Firstly, sketches are typically black and white, pencil drawings. The drawings are either completed as a whole image or in separate parts. These sketches are then redrawn on fine paper as a final image. After the final image has been drawn, I begin applying details, shading, and color using different tools. Sketching is quicker by hand and using Photoshop to resize and move things around allows me to create several options quickly before deciding on the final composition.

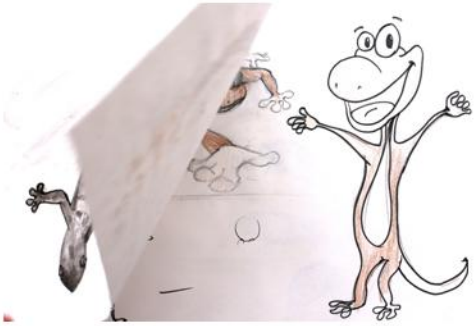


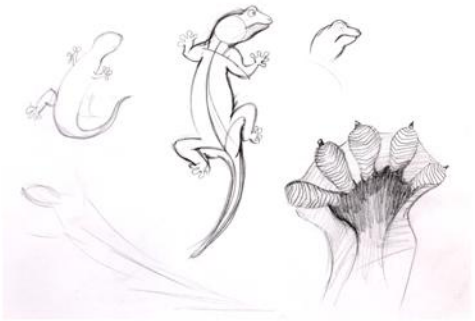
SEM Image

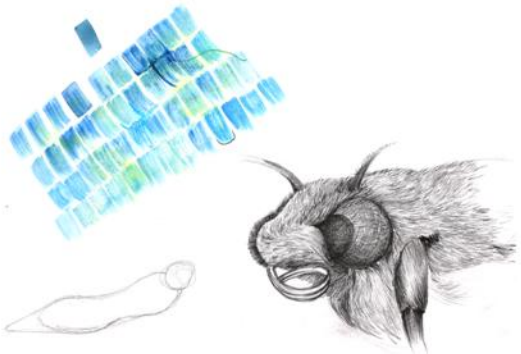
Tools

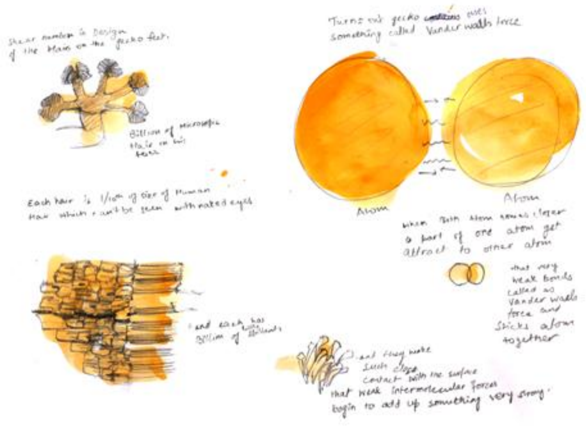
I typically choose drawing pens that contain archival ink; a waterproof and fade-resistant ink that allows for a longer lasting artwork. Drawing pens can have tips as small as 0.05 mm and in variety of colors. Pencils come in a variety of grades. The scale is based on hardness (H) and blackness (B) and range from 6H, the lightest, to 8B, the darkest. Colored pencils come in a variety of colors. Watercolor paints are often used in conjunction with pens, pencils, and colored pencils. This is done to add detail to the watercolor image after the paint has dried.

Explorations








Turns out gecko uses
something called Vander walls force
Billion of microscopic
Each hair is 1/10th of size of human
Atom
Atom
when both atom comes closer
a part of one atom get
attract to other atom
that very
weak bonds
called as
Vander walls
force and
sticks atom
together
and each has
and they make
such close
contact with the surface
that weak intermolecular forces
begin to add up something very strong.

Iteration

I experimented with format of the books. Explored the different types, shape and cutout format of book. So the basic idea behind this experiment was to create a theme based template format. For instance for moth story I made the book shape like moth eye. I cut the pages in moth eye shape to make it more relevant and engaging and filled pages with illustration and text. Then I showed to many people in order to see how this moth eye shaped book is working.

My 8th STD daughter would not prefer to read this; it's for 2nd STD kid.

DJ Mathew

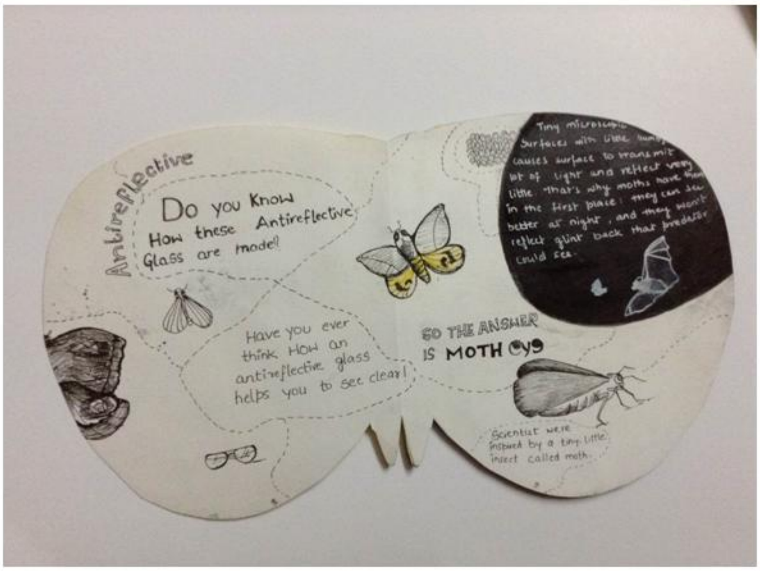
Content is good but I think this looks more for 3-6th STD student.
I would prefer normal book format with lots of technical knowledge. I illustration are also nice but you need to include more concepts.

Joshua
12th STD student

The experience with these book was negative and I dumped this ideas of theme shaped like book.


technology
that has brighten
our Lives
Inspired by an Insect
that Lives in the
Dark.
Moth

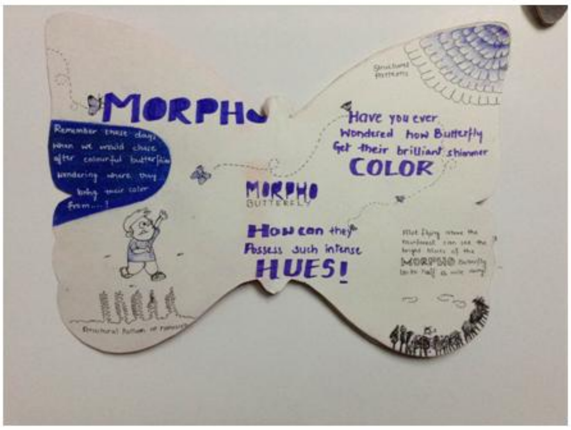

Moth eye have Evolved in nature to be antireflective which means they donot reflect visible light. This is called as moth eye effect and is important for insects to protect themselves from the Predators.


Antireflective
Do you Know
How these Antireflective Glass are made?
Have you ever think How an antireflective glass helps you to see clear!
SO THE ANSWER IS MOTH eye
Scientist were inspired by a tiny little insect called moth.
Tiny microscopic surfaces with little
causes surface to transmit lot of light and reflect very little. That's why moths have them in the first place: they can see better at night, and they won't reflect glint back that predator could see.


Morpho
Butterfly


BLUE
is a rare colour in nature and most places it is seen, due to
Structure


In morpho butterfly the wings are laid out with scales in a regular patterns. Each scale is like a tiny tile in the mosaic + the ridges on the scales are important as they are spaced perfectly to allow constructive interference of blue light and not others.


MORPHO
Remember those days when we would chase after colourful butterflies wondering where they bring their color from....!
Have you ever wondered how Butterfly get their brilliant shimmer
COLOR
MORPHO
BUTTERFLY
How can they Possess such intense
HUES!


Gecko

Finding of content and Storyboarding

After having so many discussions on content, we finalized the content and I started storyboarding those stories.

This book has different categories:

Introduction: the introductory part of the story which includes what is all about, where it started, inspiration, abilities.

Process: this part includes the function inspirations and nanostructure hierarchical organization of lotus, gecko, moth butterfly, spider.

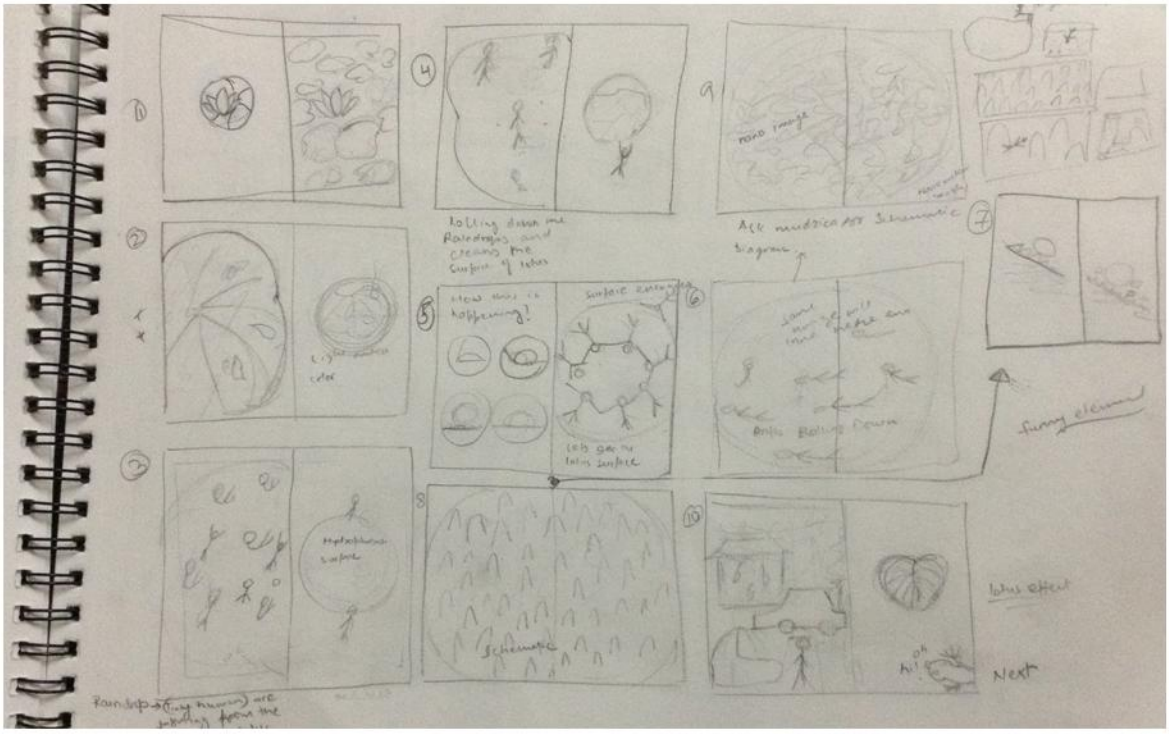
Technical: this part includes the concept of physics calculations, equations, methods number which would show in nerd zone and visual glossary

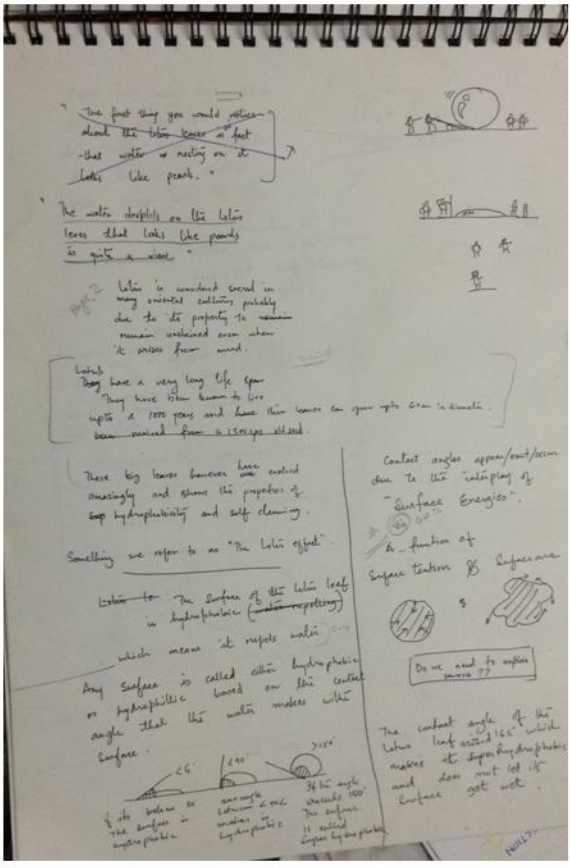
Nerd zone: we wanted to keep equations separate as we decided to have a zone which attracts those who want more in-depth technical information.

Visual glossary: this is a kind of novel which the book would have , a visual glossary in the end of the book like we see in the books. this would include diagrams charts technical image of the story

Humor: this part has been most explored in terms of presentation. I tried to simplify those complex concepts making it funny through character, Morphology etc.

Lotus


Next



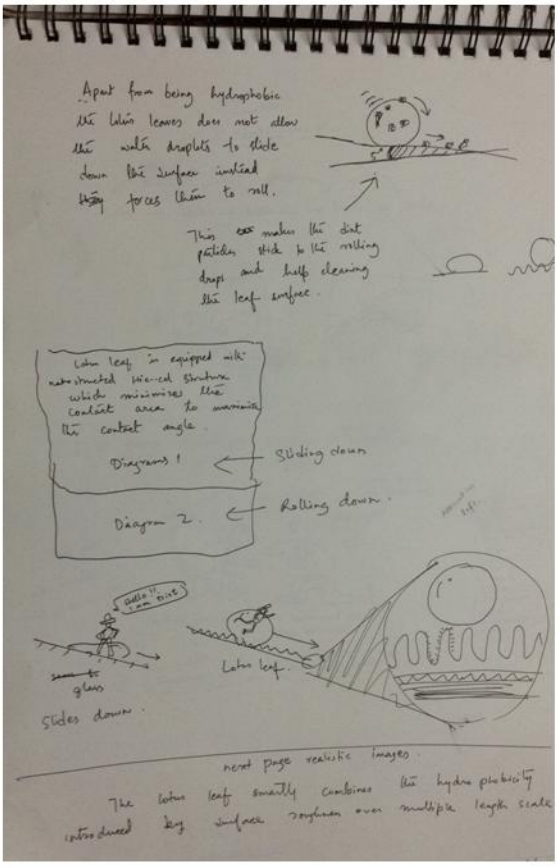
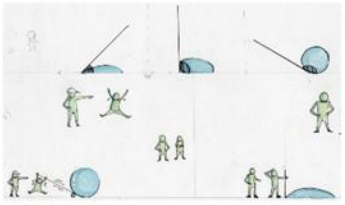


Diagram 1
Sliding down
Diagram 2
Rolling down
Lotus leaf
Slides down

Lotus grows in mud and leaves are so close to the mud, yet remains clean.
Water droplets on a lotus leaf appears like a pearl.
Lotus leaf has a self cleaning mechanism and a tendency to repel water – referred to as ' lotus leaf effect'.
Fun facts: Lotus is considered auspicious probably because it grows in mud and yet so beautiful and clean.
Lotus leaf can be as big as 60 cm.
Lotus can live up to 1000 years. Recently, a lotus has been revived from a 300 years old seed.
Lotus leaf is hydrophobic, that is, it does not like water.Hydro – water and phobic – repelling
A water droplet on a surface makes an angle referred to as contact angle, which is determined by balance of surface tension of air-water, water-solid and solid-air interface.
Contact area also plays an important role in determining the strength of interaction.
Any surface is called either hydrophobic or hydrophilic based on the contact angle that the water makes with surface. (Nerd Zone)
The contact angle of the lotus leaf is over 150 which proves its super hydrophobic behavior and therefore water does not wet its surface.



Contact Angle	Nature	Remark
0	Superhydrophillic	Wetting
0<θ<90	Hydrophillic	
90<θ<150	Hydrophobic	
150<θ<180	Superhydrophobic	
180	Superhydrophobic	Non- wetting

When the surface tilted, due to gravity, friction and of course surface tension, the advancing and receding contact angle deviate.
If advancing angle = receding angle, the water droplet rolls off.
If the advancing angle exceeds receding, the drop slides.
When the lotus leaf is slightly tilted, the water droplet quickly rolls down.

This makes the dirt particles stick to the rolling drops and helps cleaning the leaf surface. This action is self cleaning.

Hydrophobicity and self cleaning can be associated to low surface energy, but

lotus leaf is gifted with beautiful nanostructured hierarchical organization which accentuates the effect.

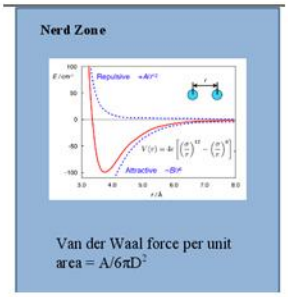
A Lotus leaf is marked with structure called papillae, which are of the order of few nm.
These Papillae causes surface roughness which reduced the contact area between water droplet and leaf. The papillae are further embellished with tubules which are coated with wax.
Not only the wax causes hydrophobicity but the minimization of the surface area reduced interaction and renders hydrophobicity.
In addition, the papillae are varying in height which further reduced the surface area in contact.

Lotus Leaf Applications:
1. Anti icing surface to be used in aircrafts and power lines: For not allowing the deposition of ice on aircraft surfaces and thus avoiding weight increase in air
2. All mobile/ display surfaces: to avoid damage due to contact with water; Now a days, IPhone is even dropped inside water, it is not damaged.
3. Self cleaning paints, fabrics, roof tiles
4. Solar panels
5. Self cleaning glasses in traffic control sensors
6. Rainwater or dew harvesting

Gecko

House lizard ambles around, sticks on a wall, without leaving a mark.

Gecko (lizard belonging to infraorder Gekkota) is often looked an inspiration for adhesion.
A gecko can attach itself to any surface rough or smooth , hard or soft.
It can attach and detach equally fast almost about 20 times/ sec.
What is the reason behind gecko's foot adherence?
Gecko's foot quickly attaches and detaches. And it does not leave an impression
All of these observations refutes all the above possible reasons behind adhesion. The adhesion is based on van der Waal's interaction.
Van der Waals forces are the forces ofproximity and its exists between any combination of molecules, atoms and surfaces when they are at a distance for few Å.
These forces are neither from covalent nor electrostatic interactions.
Van der waals forces are very weak forces and are generally attractive.
Typical magnitude for van der Waal force is of the magnitude xyz (add value) (nerd zone)
Nerd Zone



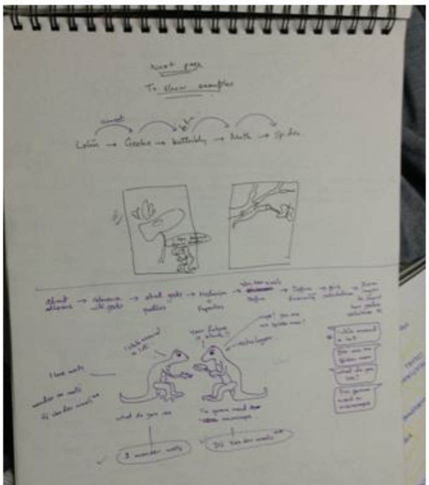
It can walk inverted and also against gravity.
Fun Facts:
A small gecko can walk up to 1m/s upwards vertically against gravity.
Gecko does not leave a mark and most importantly, its feet do not even accidently attach to each other.

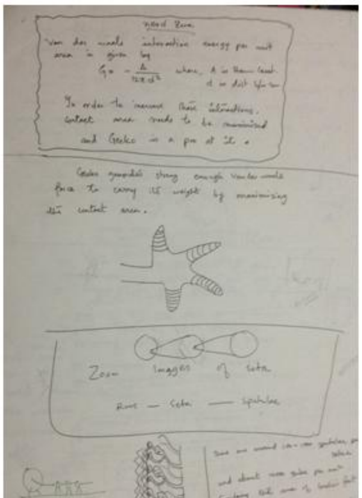
These forces are very feeble in comparison to other forces for example gravitational forces.
When the Gecko walks upside down or inverted, these van der Waal's forces need to counter weight of the Gecko. This is possible only when the contact area is maximized.
Opposite to the previous case of lotus leaf, where nanostructured hierarchical organisation reduces the contact area, the same strategy allows nature to increase the contact area.

Gecko's feet comprise of rows of structures called satae which are about 100 μm long and 5 μm wide. Each satae is divided into100-1000 spatula /mm2 which are 200 nm wide.

Gecko feet inspire primarily adhesives for different types of environment (dry and wet).
Further potential uses (you can make sketches based on this information and make a connect to the original story):
(a) Novel adhesive materials with superior properties which are likely to find uses in industries ranging from defense and nanotechnology to healthcare and sport.
(b) Adhesive could have many medical applications, for example tapes that could replace sutures to close a wound and a water resistant adhesive for bandages and drug-delivery patches.
(c) Robotics: As progress continues in legged robotics, research has begun to focus on developing robust climbers. Various robots have been developed that climb flat vertical surfaces using suction, magnets, and arrays of small spines, to attach their feet to the surface.
(d) Crawler and climbing robots can be used in the military context to examine the surfaces of aircraft for defects and are starting to replace manual inspection methods. Today's crawlers use vacuum pumps and heavy-duty suction pads which could be replaced by this material.


window
Zoom
vander wals
Next comes Butterfly
gecko skin pattern





Moth

Close cousin of butterfly moth, is doomed to a nocturnal life style.
Being a night dweller, it needs to drink in as much as moon light as possible to be able to see in the dark.
But at the same time it does not want light to reflect back from its eye. Having an eye shine, will attract the predators and thus moths want
their eyes to be absolutely antireflective.
Fun fact: When the moth is still a caterpillar its eyes are pretty much simple unlike the compound eyes possessed by the adults.
There are over 200000 species of moth known till date and all of them have developed this amazing ability to absorb light in a wide spectrum.
Antireflective means no wavelength of light should reflect or in order words, all light should be absorbed. (refer to nerd zone in butterfly)
An eye of a moth possesses nanostructured hierarchical pattern which makes it possible.Moth's eye comprises of features known as … whose dimension are of the order of….
Effectively the structure behaves like a composite medium with the … and air. The refractive index of each are … and …..
The effective refractive index will be combination of both refractive indices based on the composition.
As the light enters, a continuous change in the refractive index is observed. As the volume covered by the denser phase increases, the effective refractive index also increases. The bends towards the normal when it enter a denser medium. And gradually the light is taken in by the eye.
Moth Eye Based Applications:

NO PROPER EXPLANATION OF SPIDER SILK FOUND

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Moth Eye

while the butterflies are beautiful because of its colours seen during the day, its close cousin is doomed to a nocturnal life style.

The Moth has two major challenges

A a night dweller it ~~was~~ needs to ~~requires~~ to bask in ~~all the~~ ~~pics~~ as much as moon light as possible to be able to see in the dark.

But at the same time it does not want that light to reflect back from its eye. Having an "eye shine" will attract the predators and thus Moths want their eyes to be absolutely black.

Moths deals with these two problems pretty well and has inspired scientists to come up with antireflective surfaces to maximize the light absorption properties.

When the moth is still a catterpillar its eyes are pretty much simple ~~and~~ ~~does~~ unlike the compound eyes possesed by the adults

There are over ~~a~~ 200000 species of moths known till date and all of them ~~a~~ have developed this amazing ability to absorb light ~~fully~~ in a wide spectrum.

Moths can even detect UV light.

funny illustration

insects such as eye and also also posess the anti-reflective properties

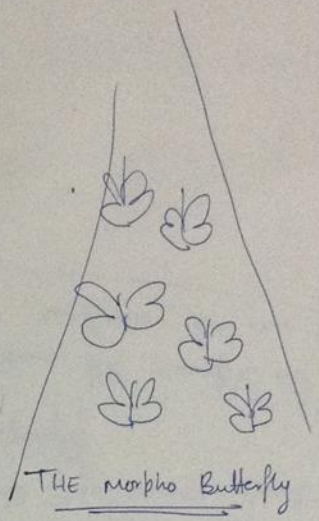
Butterfly

What would be the world without colors? Nature has provided colors in all hues and shades to different plants and animals. These bright beautiful colors undoubtedly give us immense joy and pleasure.
The colors we see around us are mostly because of the reflected light wavelength from the pigments on any surface.
This chapter discusses a special breed of butterfly which in fact uses another technique to impact color.
The retina of the human eye comprises of rod cells and cone cells which are sensitive to light. The cone cells are responsible to sense colors which reaches the eye determine the colors.
The morpho butterfly structured its wings in such a way that it scatters light. Since the blue wavelength is scattered more, the butterflies appear bright blue in color.
The same mechanism is shown by a multiple animals.
The bright changing colors of peacock feathers.
The different colors are perceived when the bird moves and the angle of incident light changes different colors are seen from different angles.
Color changing skin of chameleon.
The skin of the chameleon have nanoshapes which changes shape to diffract the wavelength corresponding the surroundings and helps it blend with the background.
These leads us to understanding of photonic crystals.
Photonic crystals are the optical wave guides.
A direct parallel would be to create active or adaptive military camouflage fabrics that vary their colours and patterns to match their environments, just as chameleons do.
2. The ability to vary reflectivity to different wavelengths of light could also lead to efficient optical switches that could function like transistors

What would be the world without colours? Nature has provided colors in all hues and shades to different plants and animals. These bright beautiful colours undoubtedly gives us immense joy and pleasure.

The colours we see around us are mostly because of the reflected light from the pigments on any surface. wavelengths

This chapter discusses a special breed of the butterfly which in fact uses another technique to impart color

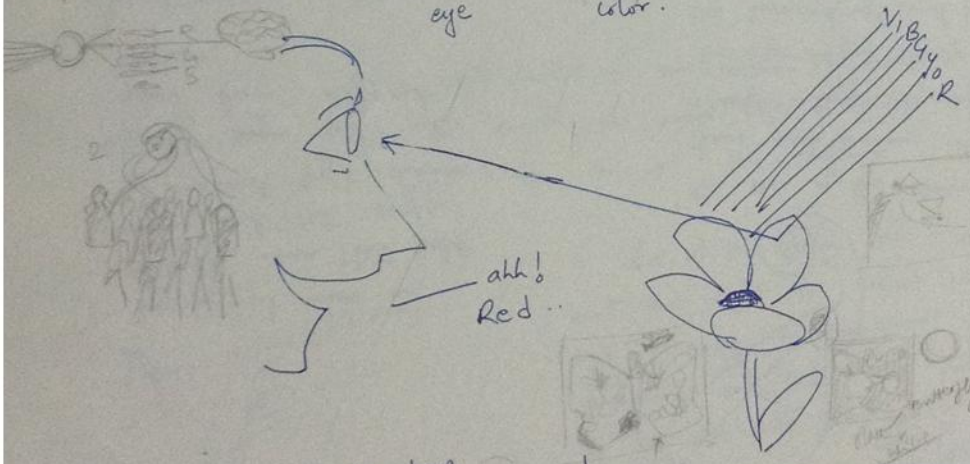


THE morpho Butterfly

The Retina of the human eye comprises of Rod cells and cone cells which are sensitive to light. The cone cells are responsible to sense colors

eye

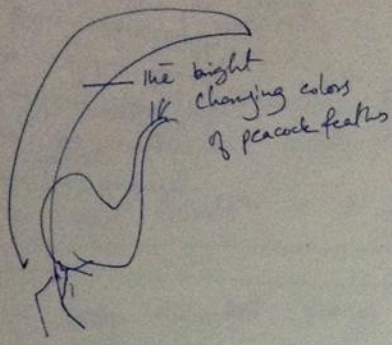
normally the wavelength of the light which reaches the eye determine the color.



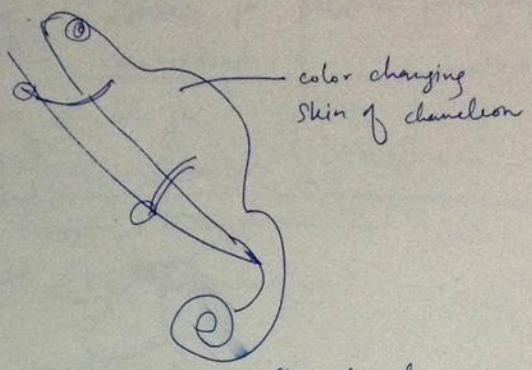
The morpho butterfly have structured its wings in such a way that it scatters light. Since the blue wavelight is scattered more, the butterflies appear bright blue in color.

Images to explain hierarchical structure of the wings.

The same mechanism as shown by a multiple animals.

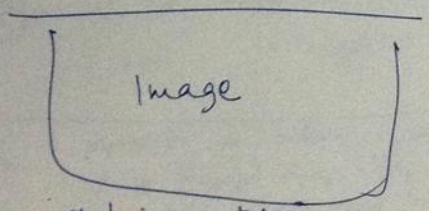


The different colors are perceived when the bird moves and the angle of incident light changes. Different colors are seen from different angles.



The skin of the chameleon, have nanostructures which changes shape to diffract the wavelength corresponding the surroundings and helps it blend with the background.

This leads us to the understanding of photonic crystals.



photonic crystals are the optical wave guides

The understanding and replicating from nature can enable color changing paints, low energy vibrant displays.

[leave the example and conclusion for now]

Spider silk

Nature has its ways to meeting its necessities and in this chapter we are discussing the amazing properties of a natural fiber SILK
For years now silk is being used in fishing fibers, parachutes, insulation coils, tires medical dressing and suture material.
Its tensile strength is comparable to steel yet some silks are merely as elastic as rubber and it reveals toughness that is 2 to 3 times that of synthetic fibred like nylon.
Spider silk is also antimicrobial, hypo allergenic and completely biodegradable
What makes silk so special? You must have heard about the reason while purchasing your new TV liquid crystals.
Liquid crystals are phases which posses order likes crystals and flow like liquid.
An isotropic material has no order in its molecules, that is properties are same in all direction and when some order arises, there is a possibility of anisotropy coming into the system, especially where the building elements are anisotropic as well as rigid.
Spider Silk overtakes the qualities of all the other fiber man has ever created.
Although spider silk has been majorly known for luxury garments, its properties stretch way beyond clothing.
An isotropic material has the capability of framing an anisotropic phase which has order but can still flow like a liquid.
Why ordering happens? A transition from isotropic to liquid crystalline phase happens due to decrease in temperature or increase in concentration.

The transition happens in response to maximize entropy. As the concentration goes up, the available free volume per element decreases and entropy also decreases. In order prevent some decrease in entropy, the elements align trying to maximise translational entropy
In context of a fibre like silk, if a fibre is made out of liquid crystalline suspension, the orientation within fibre is better and thus the
properties.
Silk is made up of protein chains, which are bonded together through H-bonding and van der Waals interactions.

Protein chains assemble to form B sheets which further assemble to form nanocrystals.
Further up the assembly, the semicrystalline silk fibrils are formed which comprise of both crystalline (nanocrystals, ordered) as well as amorphous (disordered) regions.

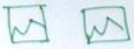
Combination of crystalline and amorphous regions provides the strength as well as toughness. (diagram – crystalline region good for tensile and amorphous good for toughness)
Such a structure is achieved by liquid crystalline processing.
Silk can be obtained from spider as well as silkworm. Spider silk is superior to the silkworm silk. There are basic difference which causes differences in the properties.
Silk comprises of two main regions– crystalline and amorphous. When a tensile force is applied, the amorphous regions unfold leading to elongation and crystal fragmentation leads to failure. In spider silk there is an additional regions, loosely bound beta sheets, which gives additional strength and toughness.

Various kinds of silk may be obtained from the Spider web - dragline, flagelliform etc
Compared to silkworm silks, the potential commercial applications for many spider silks are still extremely finite due to reasons such as difficulty of high-density spider farming, which is limited by the cannibalistic nature of most spiders. Additionally, only ~12 m of silk can be obtained from a complete spider web, this is extremely small in comparison to the 600 to 900 m of silk that is yielded by one
silkworm cocoon.
Spider silk applications

Bullet-proof clothing
Wear-resistant lightweight clothing
Ropes, nets, seat belts, parachutes Kevlar sail
Rust-free panels on motor vehicles or boats
Biodegradable bottles
Bandages, surgical thread
Artificial tendons or ligaments, supports for weak blood vessels.

R-2

Liquid crystals are phases which possesses order like crystals and flow like liquids.



glassy An isotropic material has no order at all in its molecules that is its properties are same in all direction. And when some order arises, there is a possibility of anisotropy coming into the system, especially where the building elements are anisotropic as well as rigid.

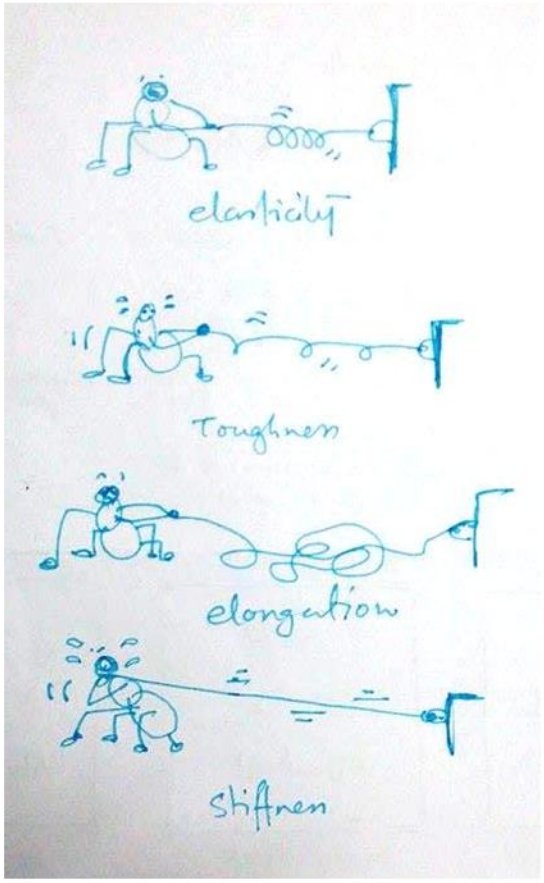
Isotropic → Gases & Liquids | Anisotropic → solids.

An isotropic material has the capability of forming an anisotropic phase which has order but can still flow like a liquid.

This ordering happens due to decrease in temperature and increase in concentration.

As the concentration goes up, the available free volume per element decreases resulting in the decrease in Entropy. Now materials dont like to decrease their entropy so to prevent this the elements try to align themselves to atleast maximize their translational entropy.

In content of Silk, if the fibre is made out of liquid crystalline suspension, the orientation with in the fibre is better and thus the properties.



Chapter 3
Visual language

Visual language

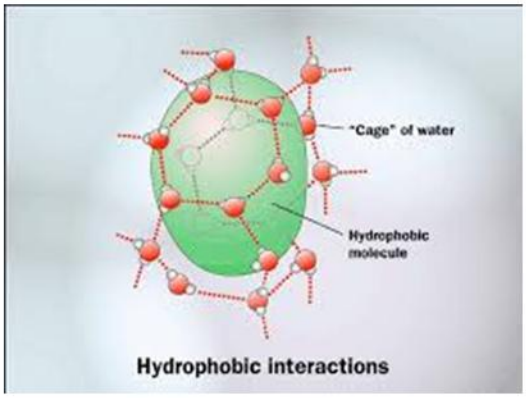
The main objective of this book is to inspire and engage students into leaning and imagining new possibilities in the field of science and technology. To awe them with artistic and detailed illustrations that opens their imagination. I wanted to keep a nuance in the subject that the students find a compulsion to keep reading the book thoroughly till the end.

The general idea in the beginning was to keep a visual language which is same and consistent throughout the book, however the illustrations are too detailed and expressive. A compilation of such large number of images all at once might feel intimidating and monotonous since we were keeping the text to a minimum. To break this i broke the usual convention of designing a book with the same visual language in all the chapters and decided to have a different style in each chapter inspired by the topic itself and while keeping the consistency through the structure of the content.

For example, Moths have this nocturnal dark color to be able to blend to the environment. The color saturations are very minimal and the entire properties are based on light and shade or dark and bright. So i kept the visual style around these parameters of shades and created a style which is similar to the nocturnal habitat of the moth.

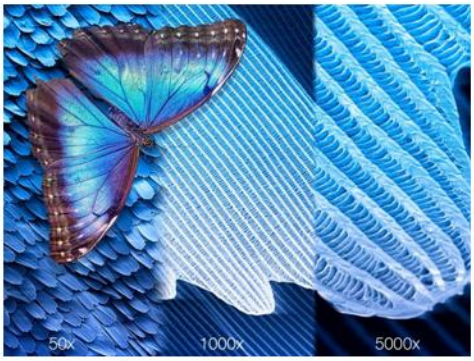
Lotus With reference

The color palate is green and blue . Tried to give it splashy look.

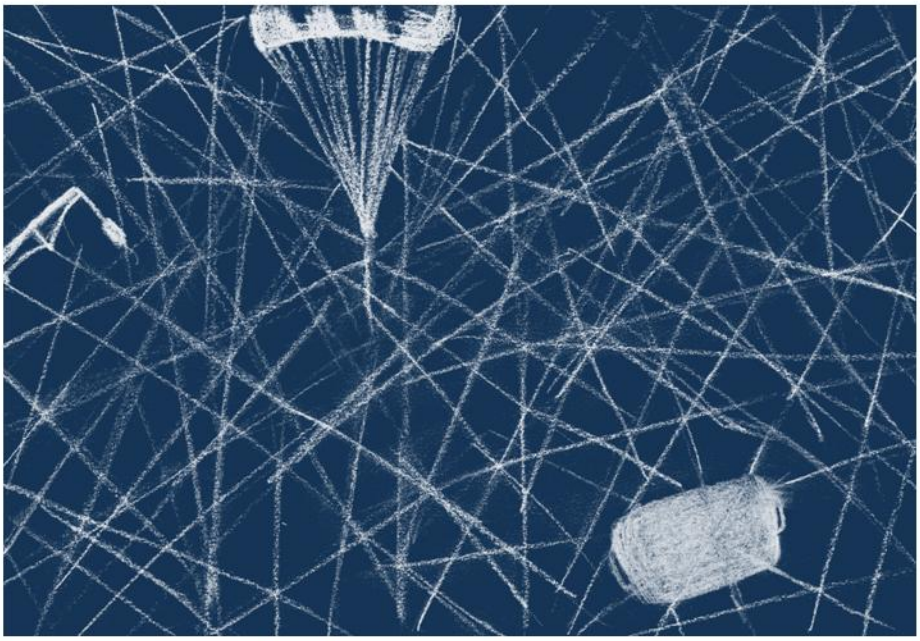


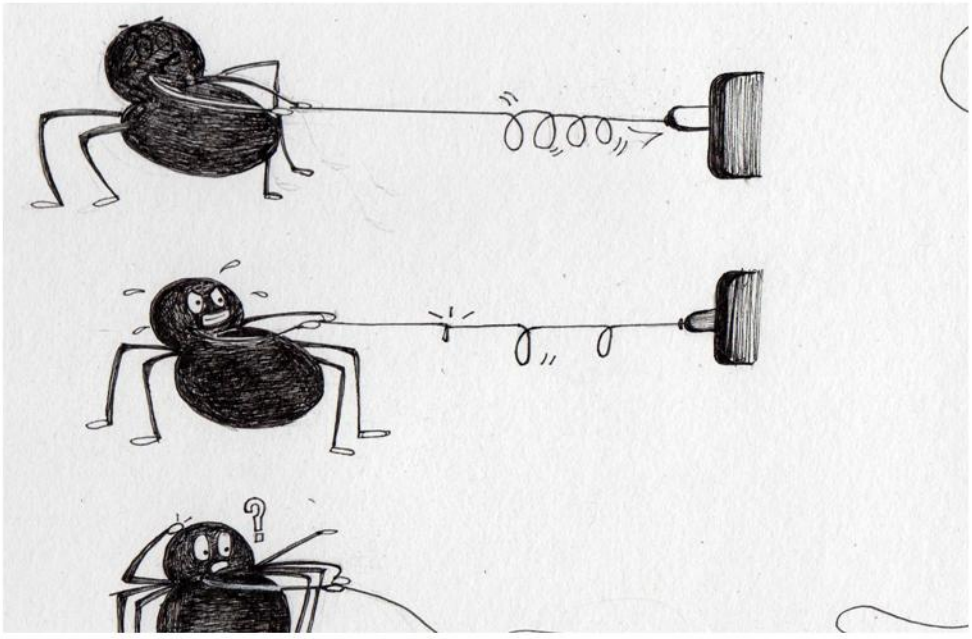
Moth With reference

Butterfly With reference

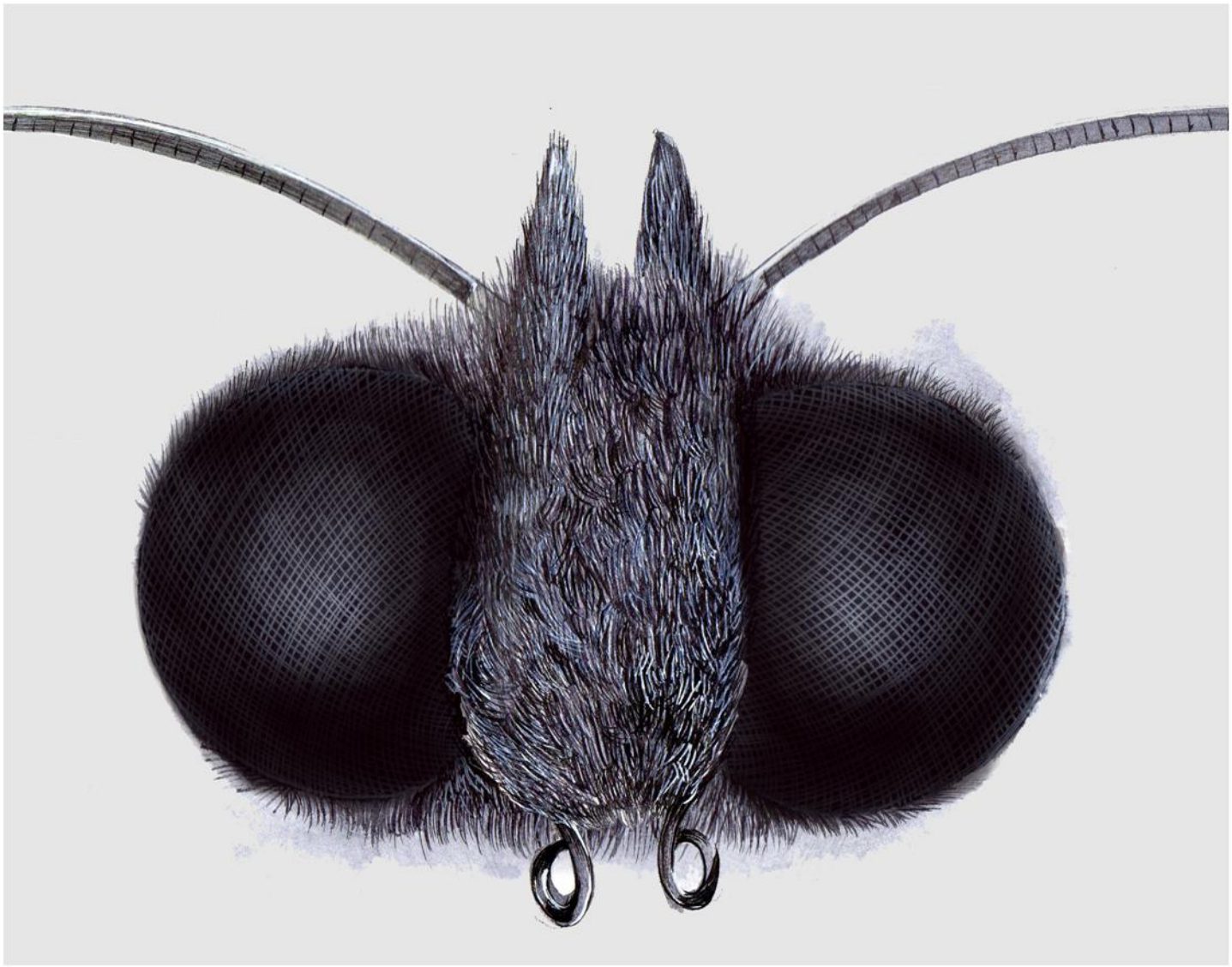


Spider silk
With reference





Chapter 4
Execution



Conclusion

This project was a contribution to greater awareness and understanding of technology through the use of image that the reader could relate to.

I felt and suggest that it is essential to design curriculum materials more creative and learning environment that can inspire and engage student more towards the subject.

According to Phyllis, in his book scientific illustration A guide to biological, illustration in science subject has a specific kind of visual communication. This communication can pass from scientist to colleague, teacher to student or research foundation to layman. so the responsibility of an artist is to draw and must be aware of the viewers level of knowledge and must relate the message in logical sequence without confusing them. Supporting the word by Phyllis, the illustration here in the book deals with more logic and technical terms having aesthetic essence.

This project helped me in gaining new insight and deepens my understand ing of the way the visuals works from meaning perspective. Illustration works well when properly executed.

I realized that illustration promote a feeling explorations and playfulness when text is bogus. Also stimulate curiosity and excitement about science as it has does to me.

Brainstorming, storyboarding and survey helped me in analyzing the co tent and how to present in best way.

I have always been fascinated by the combination of science and art. This project was a big opportunity for me to pursue my interest for science and art. I got the opportunity to learn a totally new subject biomimicry including nano hierarchical structure, physics concept and being able to

communicate these concepts.

One of the biggest realization during this project how this complex diagram can be told in simple way and how science turns more interesting when it collides with art.

One experience I am sharing here that when I got to exposed to those I inspiration from nature. I felt it was all around me i just need to observe thing closely and inspired me to learn more.

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