Science and Art: A Fantastic Combination

Tierney Brosius

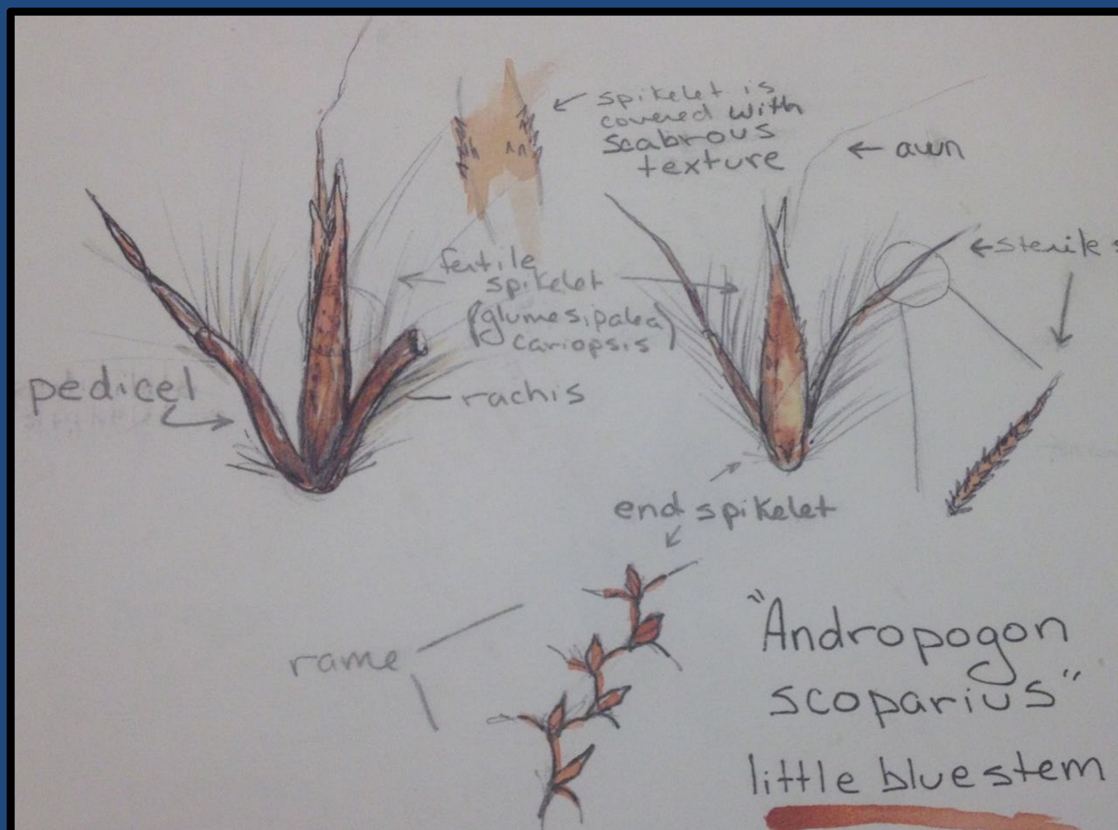
Augustana College

How did I get to this point?

- **Just a regular kid… loved drawing and nature**

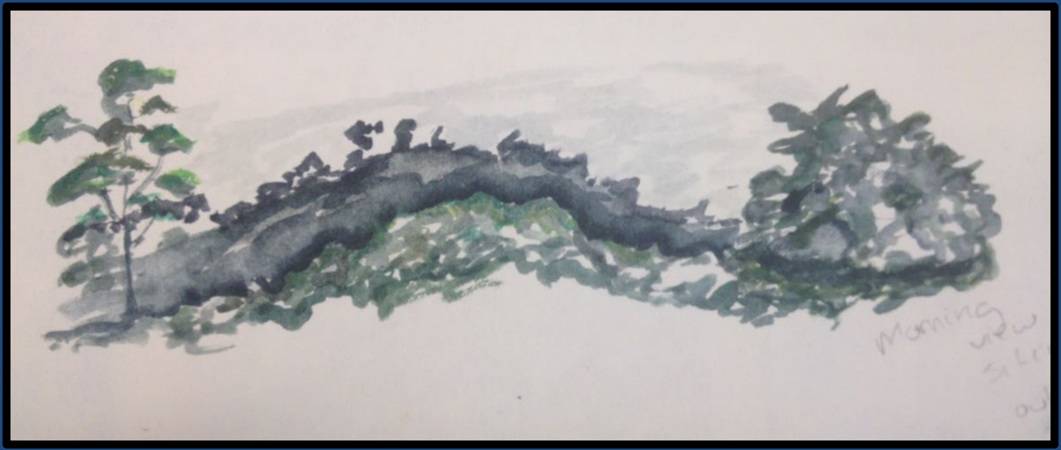
How did I get to this point?

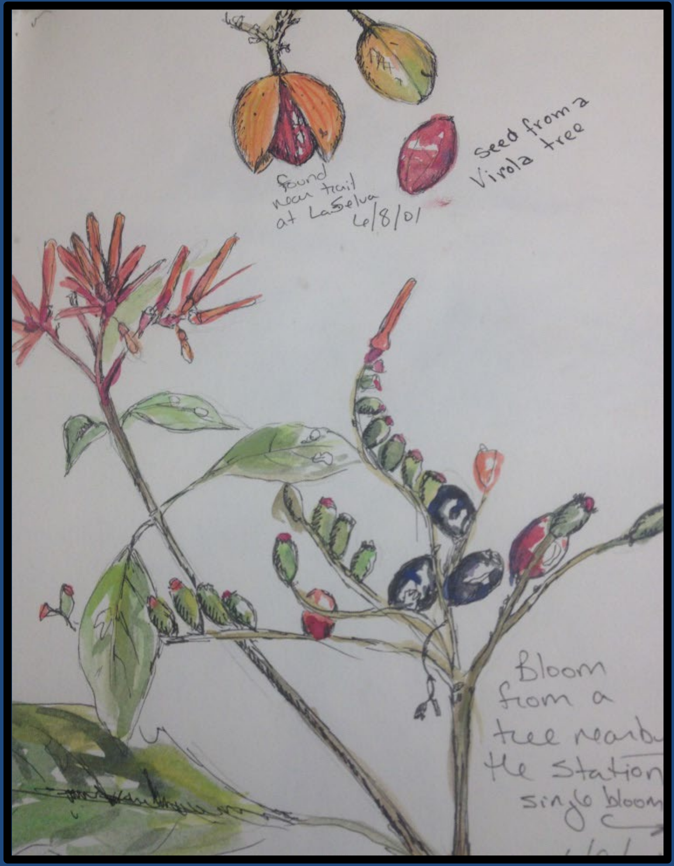
- Undergraduate research – what it taught me about illustrating



Looking Back

- **How drawing impacted my memories and improved my learning**





Entomology Professor at Augustana College

AUGUSTANA COLLEGE
1860
ROCK ISLAND • ILLINOIS

Science

DEPRESSED SUPERCOOLING POINT AND INCREASED GLYCEROL CONCENTRATION IN OVERWINTERING ADULT TIGER BEETLES (*Cicindelida*)

McKenna Burns[1,2*], Dan Herrera[1], Tierney Brosius[1], and Timothy J. Muir[1]

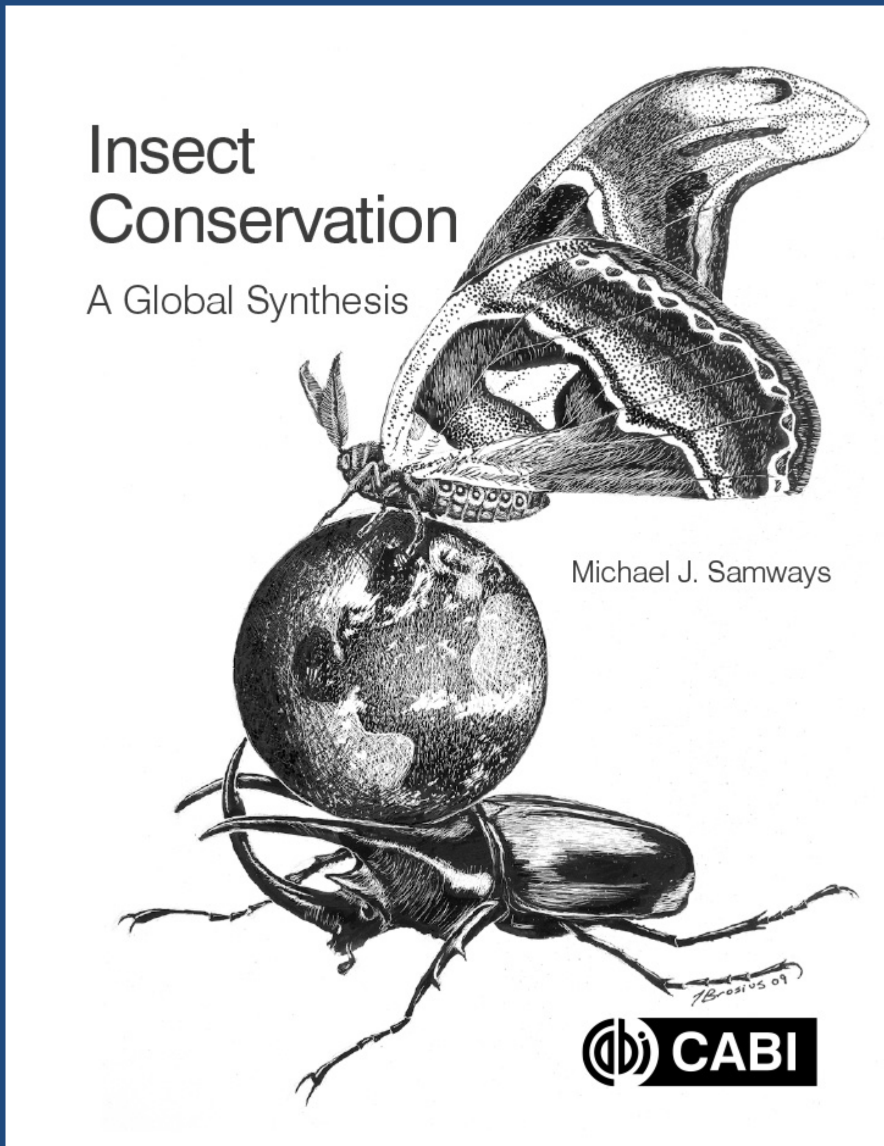
[1]Department of Biology, Augustana College IL, Rock Island, IL 61201, USA
[2]Department of Biology, Miami University, Oxford, OH 45056, USA
*Corresponding author: burnsmp3@miamioh.edu

Abstract

BACKGROUND: Tiger beetles are a widely distributed group including species that may be exposed to sub-freezing temperature overwinter. Despite being well studied, little is known about tiger beetle cold tolerance. **OBJECTIVE:** We investigated seasonal changes in cold hardiness of two northerly distributed tiger beetle species (*Cicindela repanda* and *Cicindela limbalis*). **MATERIALS AND METHODS:** We monitored the supercooling point (SCP), glycerol concentration, and hemolymph osmolality of adult tiger beetles during a 3.5-month acclimation to winter. **RESULTS:** SCP decreased during winter acclimation for *C. repanda*, but not for *C. limbalis*. Both species modestly increased glycerol concentration, and *C. repanda* increased hemolymph osmolality by 38%. **CONCLUSION:** This initial investigation into the cold-hardiness of adult tiger beetles suggests that they are capable of lowering their SCP as winter approaches, which may help them survive sub-freezing winter temperatures. F
conditions in th

Keywords: tige

Art


Insect Conservation
A Global Synthesis
Michael J. Samways
CABI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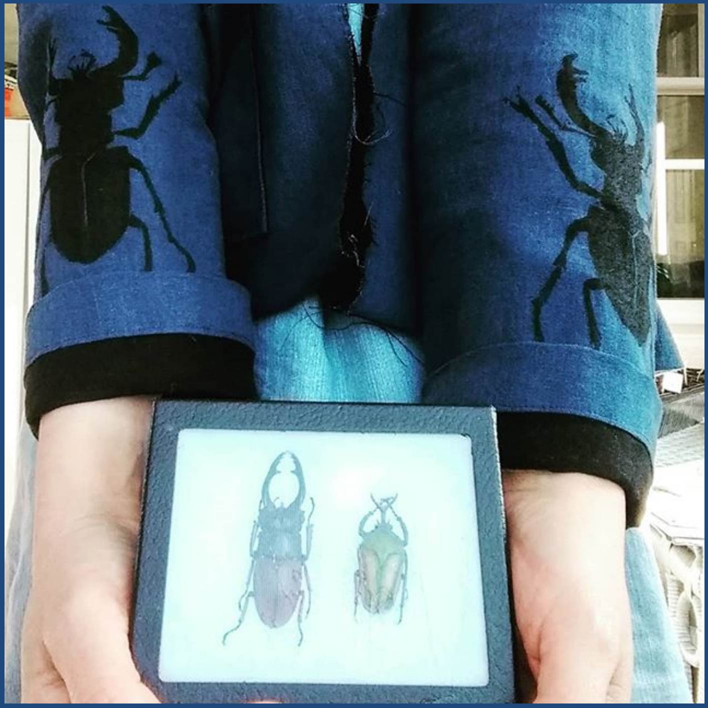
Art



Entomology and Fashion @dr.beetle

Science and Art

Promoting the Conservation of the Salt Creek Tiger Beetle Using the Visual Arts

TIERNEY R. BROSIUS, LEON HIGLEY, AND LANA JOHNSON

Many challenges lie ahead for humankind as we attempt to correct the environmental damage caused by human activity. Two of these challenges are tied to collective apathy towards the environment: we must instill an appreciation for nature in a society that is becoming increasingly detached from the natural world, and reverse public perceptions that biodiversity is unimportant and not worth our resources to preserve (Cardoso et al. 2012, Kremen et al. 1993, New 1999, Zamin et al. 2010). The greatest biodiversity on our planet is phylogenetically distant from ourselves and consists of species considered to be non-charismatic. Society may downplay the significance of these groups of organisms, but our existence, along with the rest of the "charismatic megafauna," would not be possible without the presence of creatures that most people consider insignificant (Wilson 1987). For instance, the value of the services provided by insects to Americans is placed at more than $57 billion (Losey & Vaughan 2006), and when all invertebrates are included, this figure jumps to $33 trillion (Costana et al. 1997).

Public perception is important to the success or failure of any conservation effort. Yeffee et al. (1996) states that "public opposition is the major constraint to implementing ecosystem management plans in the United States," and Cardoso et al. (2011) lists the issue of public perception as one of the seven impediments to invertebrate conservation. If it is true that insects and other invertebrates are not commonly perceived as worthy of protection, how can we address the challenge of a society that is seemingly uninterested in the preservation of over 99% of animal biodiversity? For example, a survey conducted by Kellert and Berry (1980) found that while 89% of respondents agreed that the bald eagle should be protected, only 25% agreed that

Fig. 1. Oil painting by Jessa Huebing-Reitinger for Salt Creek tiger beetle art exhibit. 60" x 44".

What is common ground between science and art?

Science is making observations

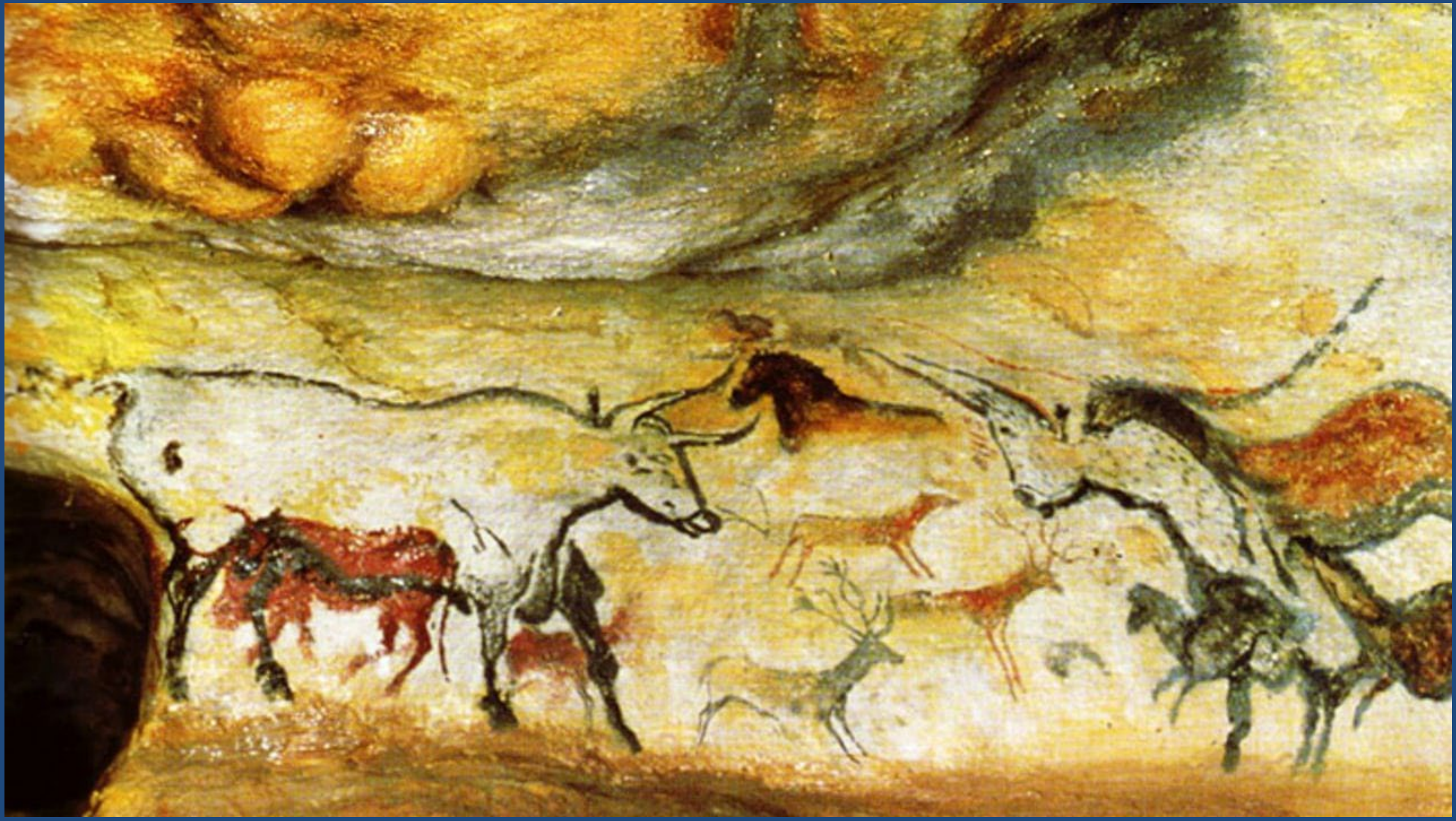
In the realm of scientific observation, luck is granted only to those who are prepared.

~ Louis Pasteur

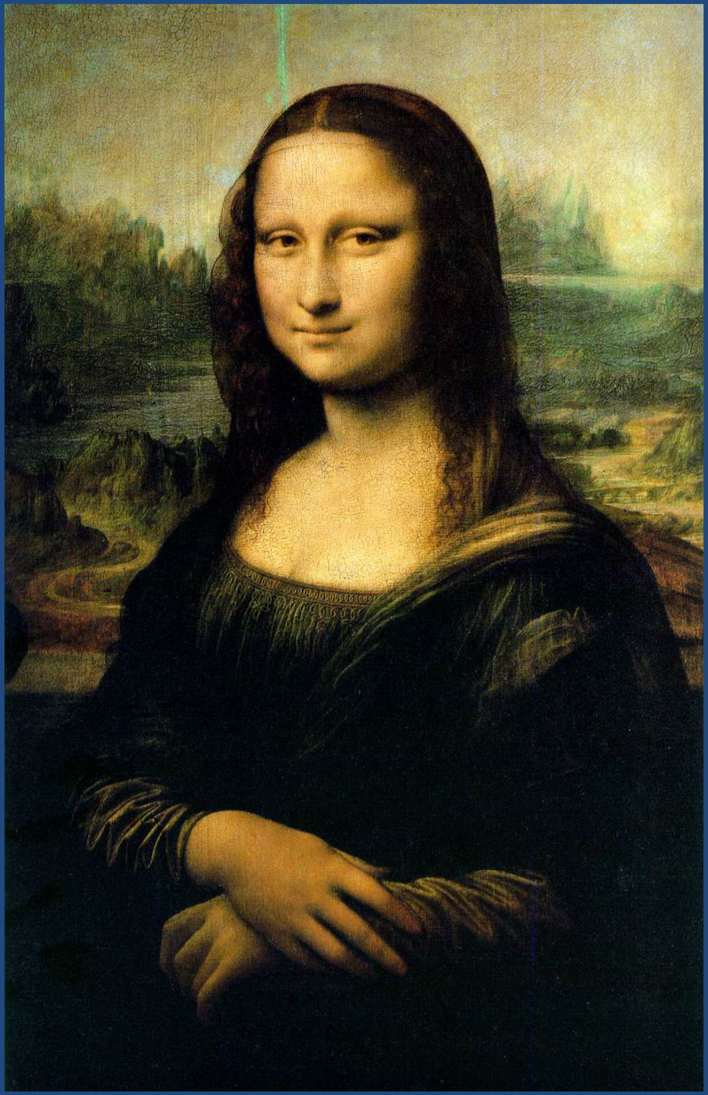
Deep Seeing

Early Science or Art?

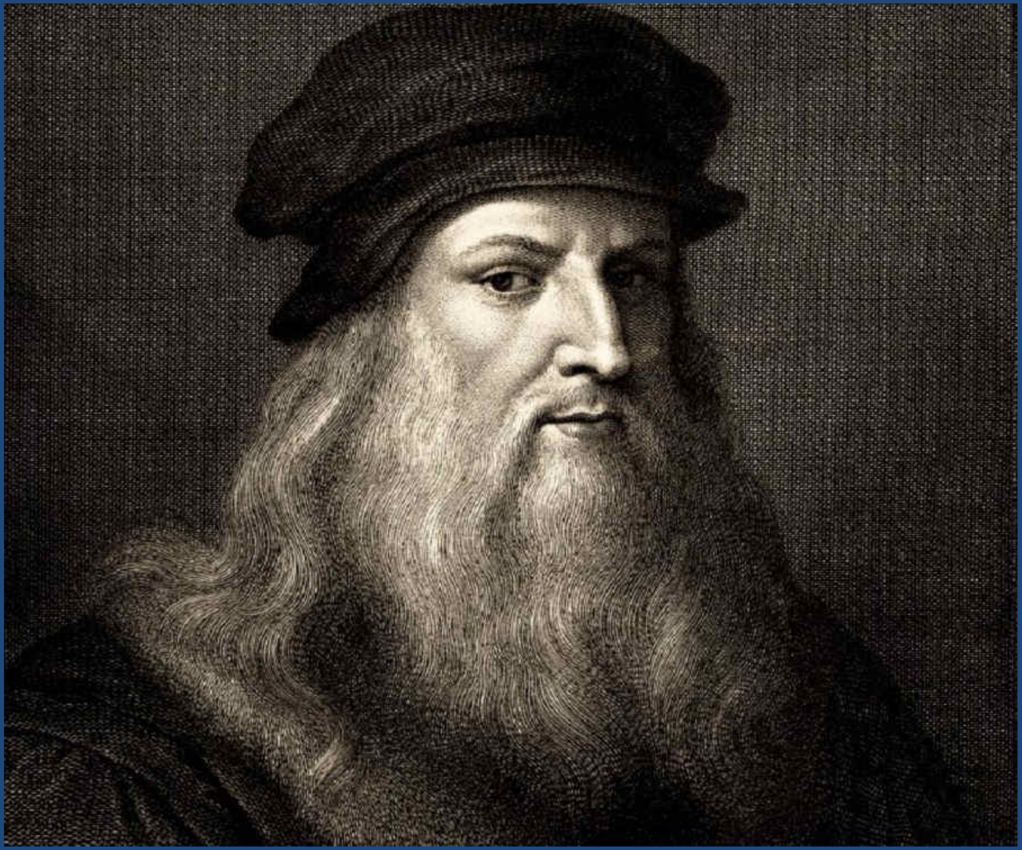
Lascaux, France

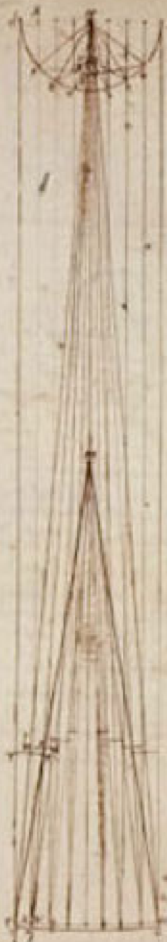


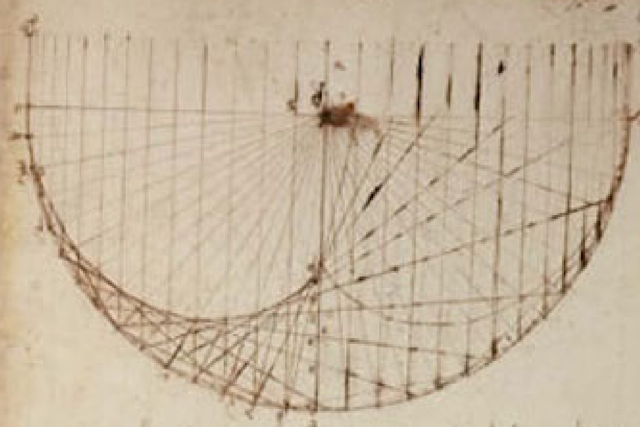
Leonardo da Vinci

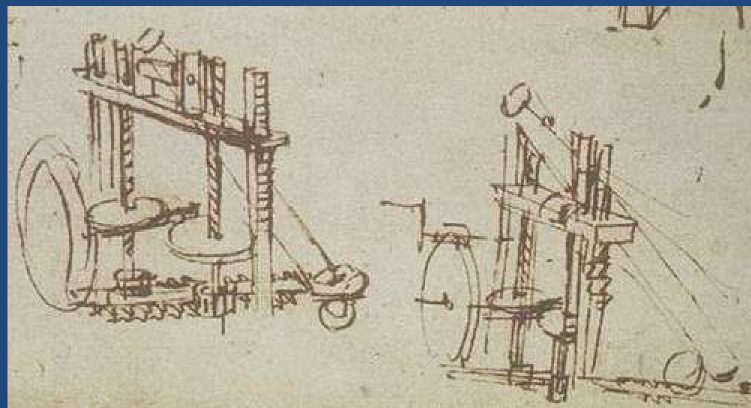


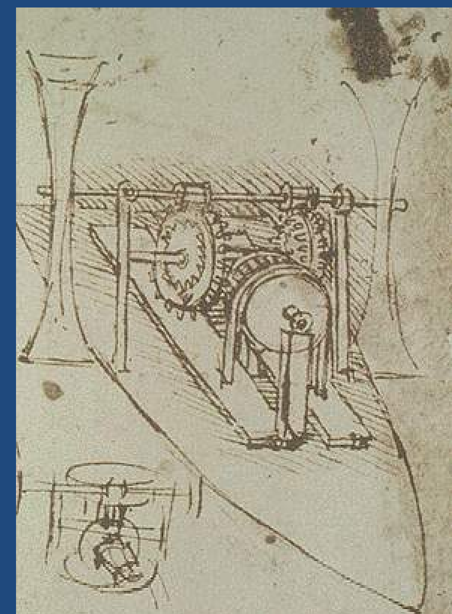
Know to See

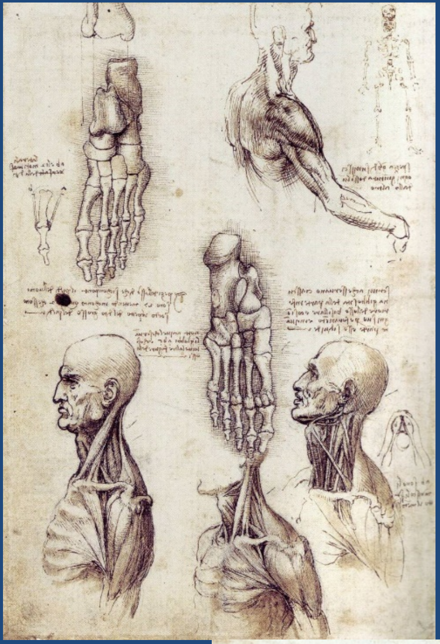


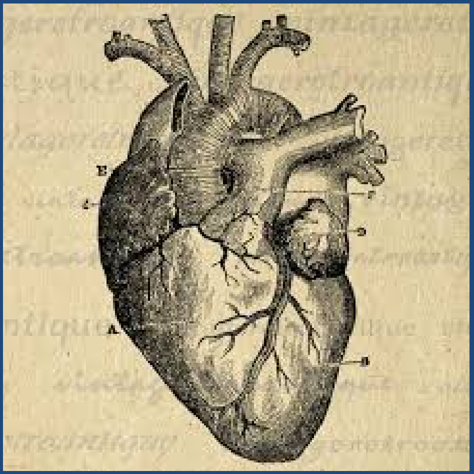


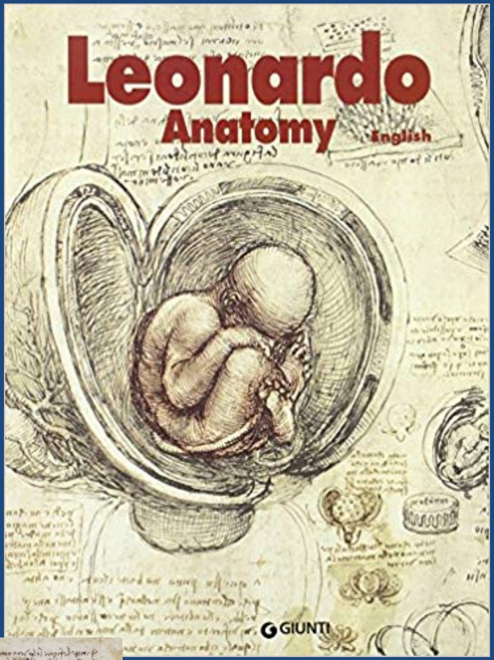


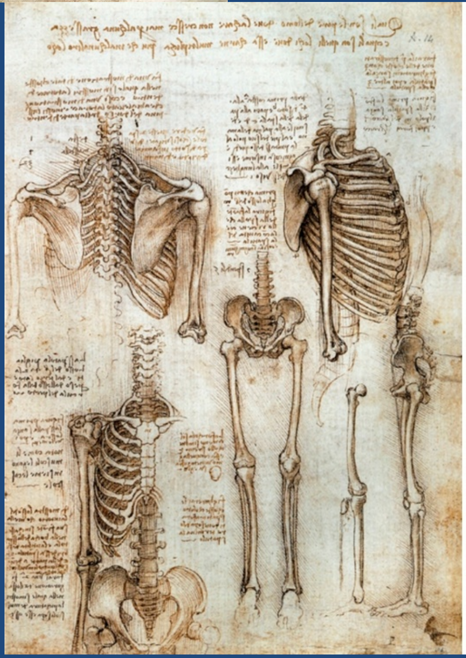


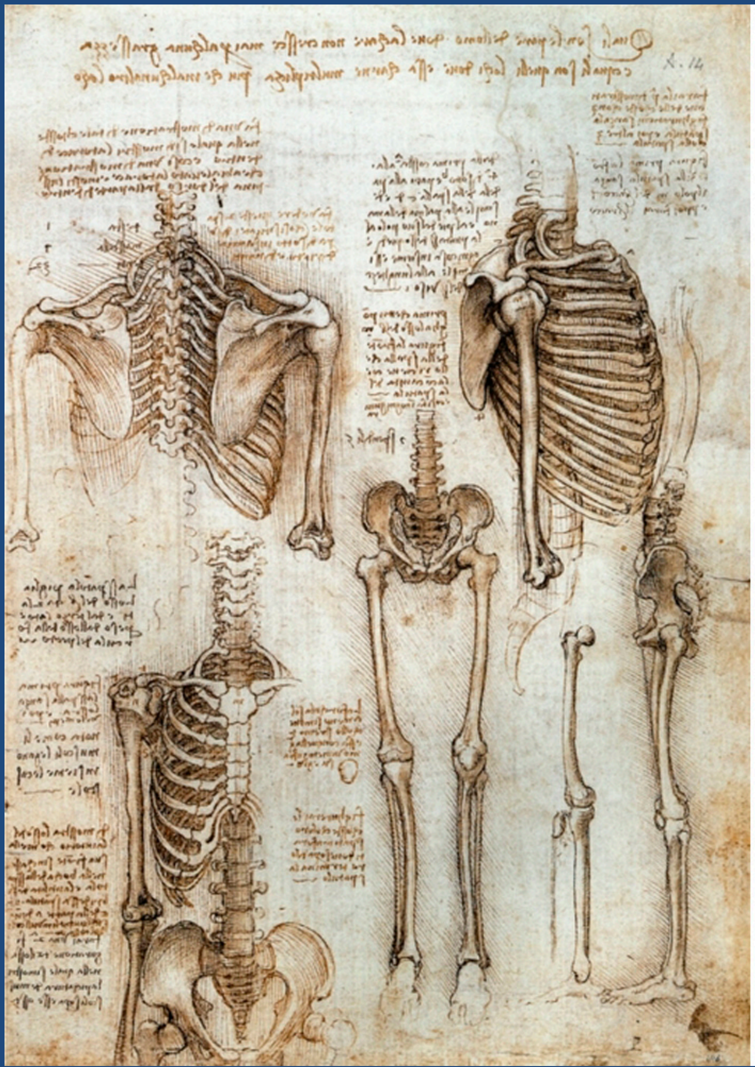


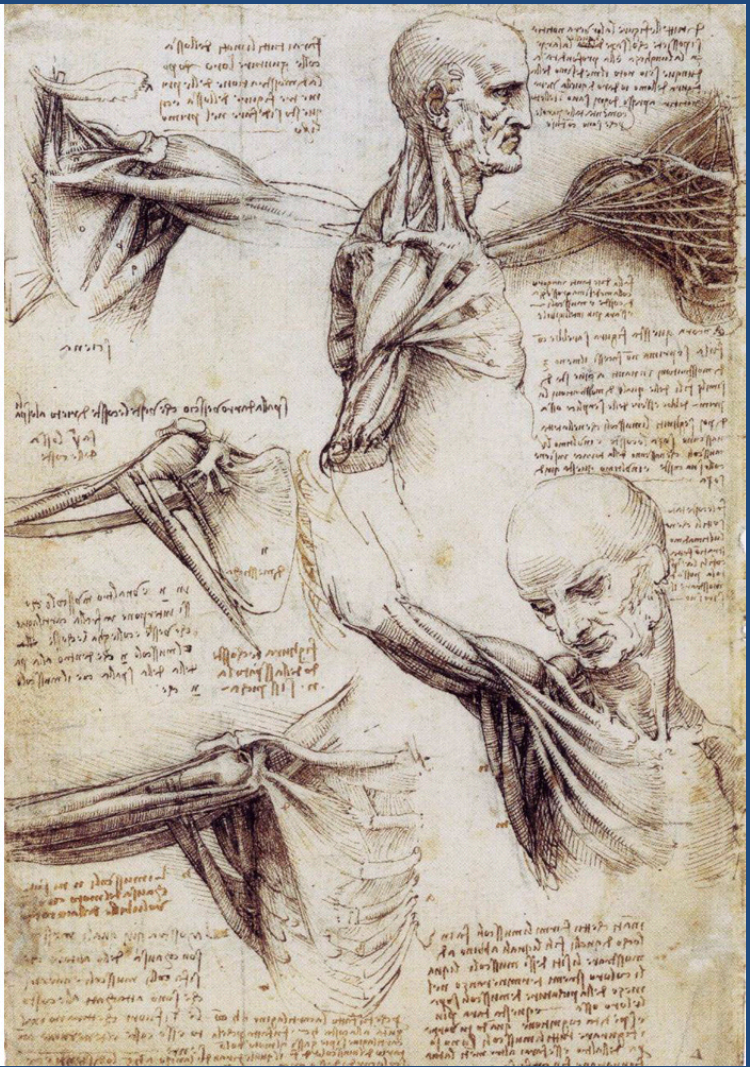




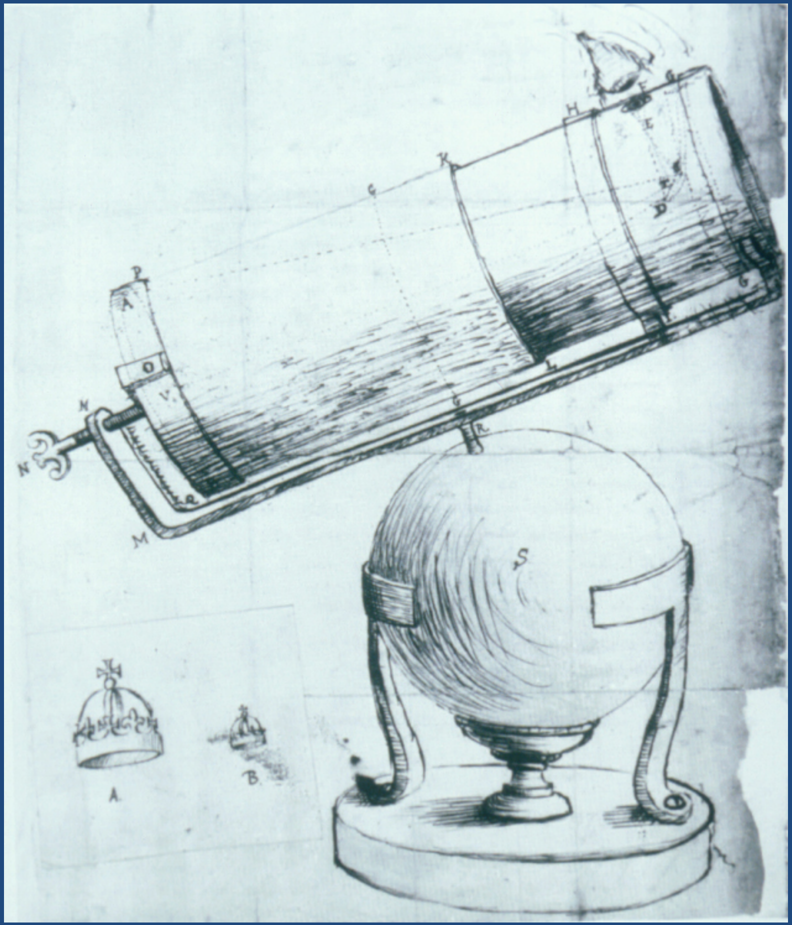

Leonardo
Anatomy
English
GIUNTI







Issac Newton



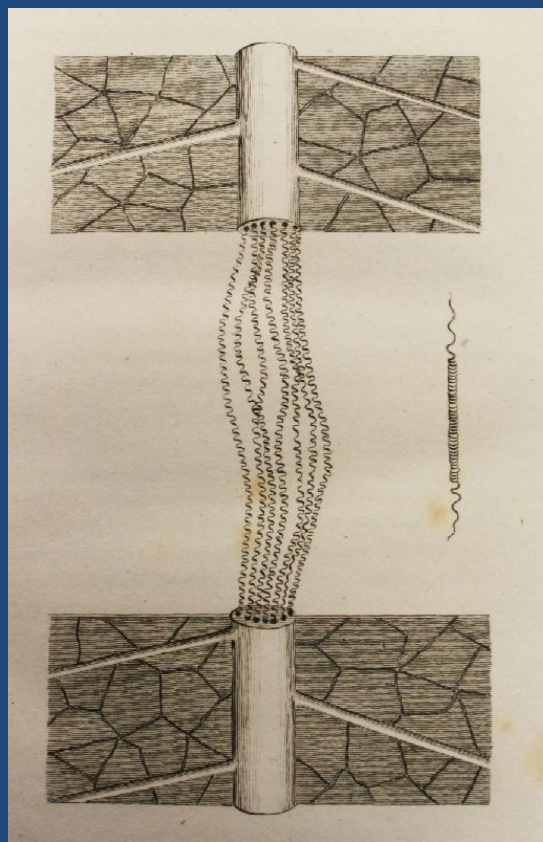
Maria Sibylla Merian

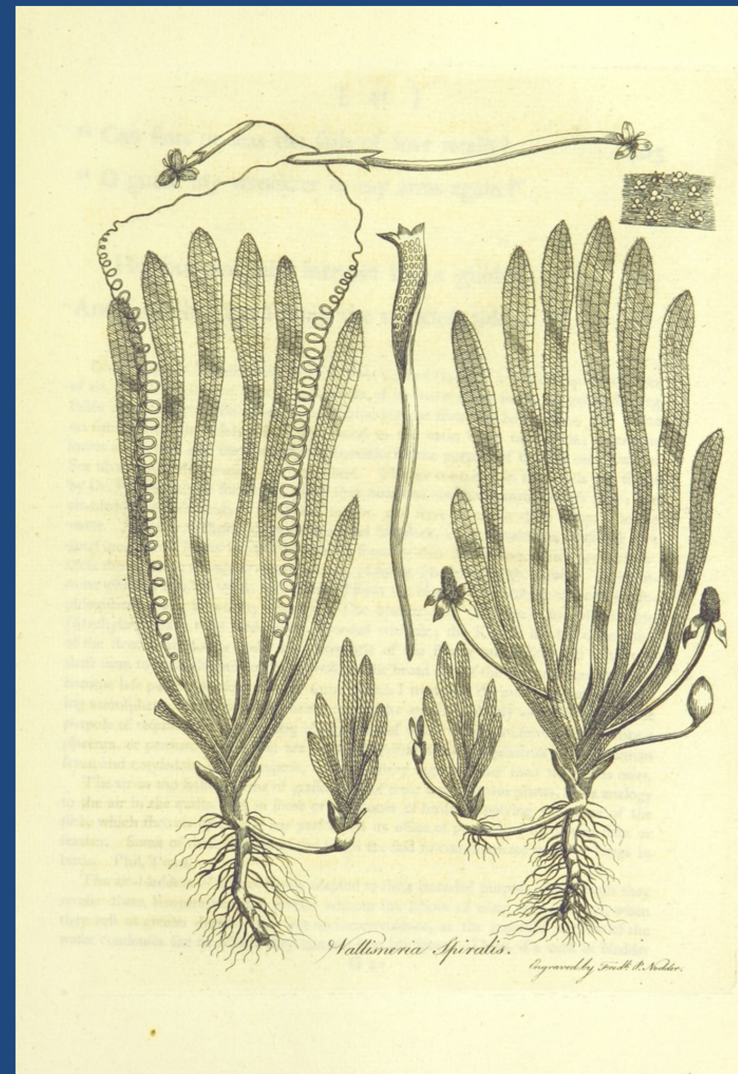
1647-1717

Illuminated Copper-engraving from *Metamorphosis insectorum Surinamensium*, Plate VI. 1705 by Maria Sibylla Merian.

Erasmus Darwin

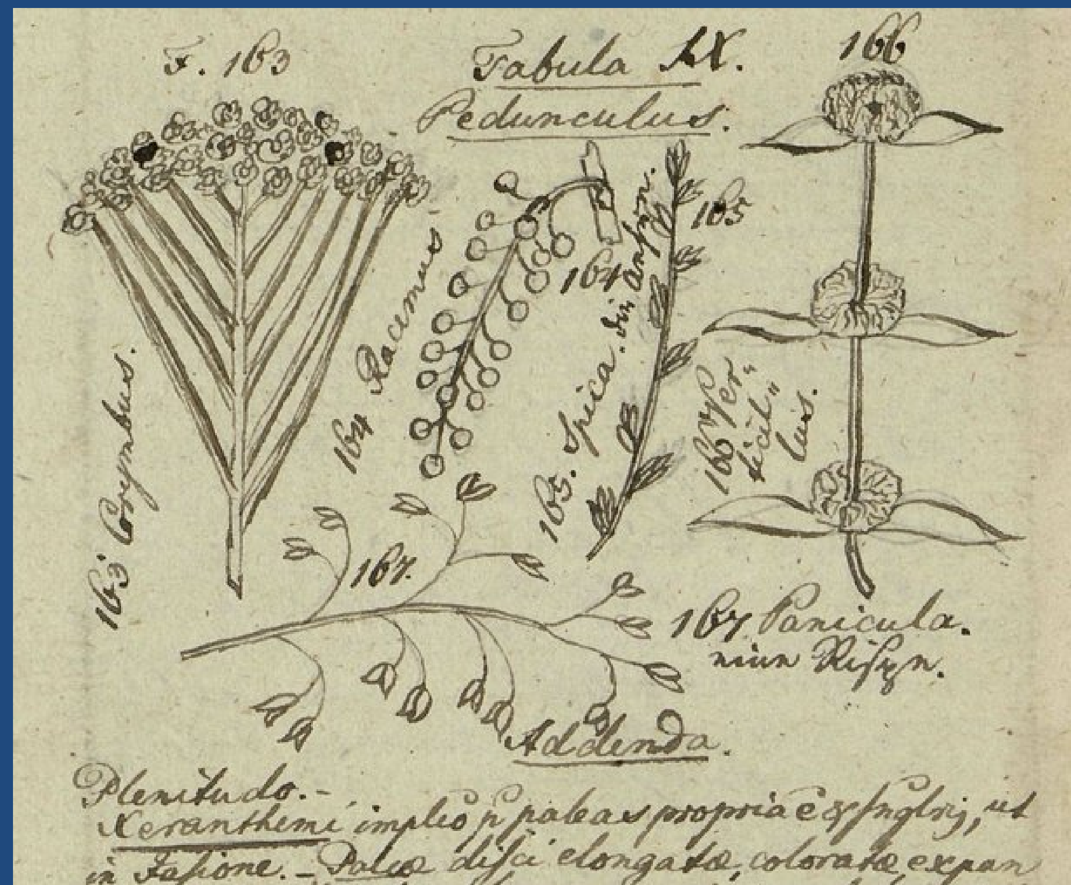
1731–1802





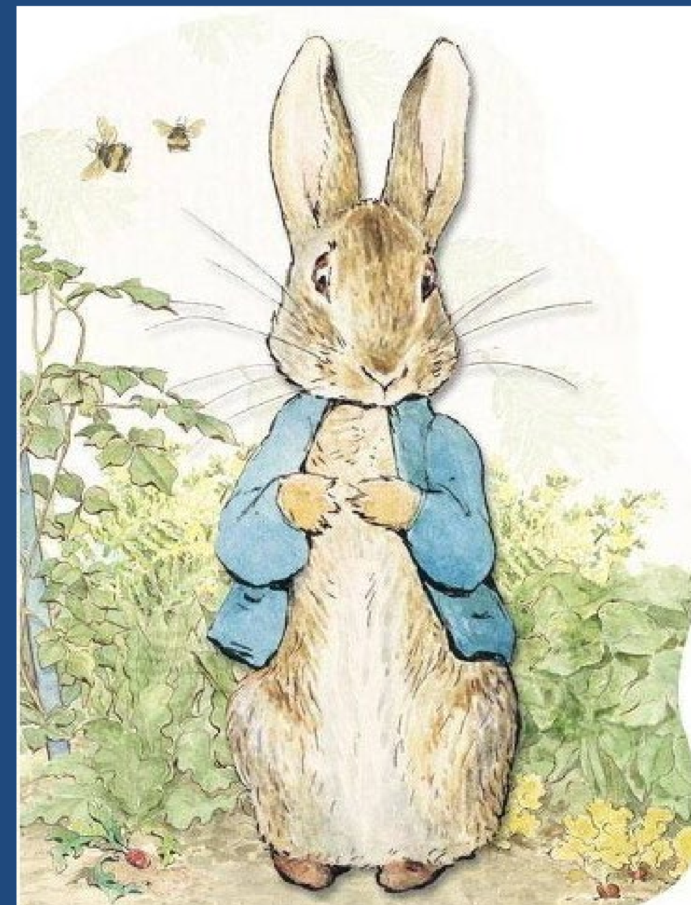
Carl Linnaeus
1707–1778

Father of taxonomy



Beatrix Potter

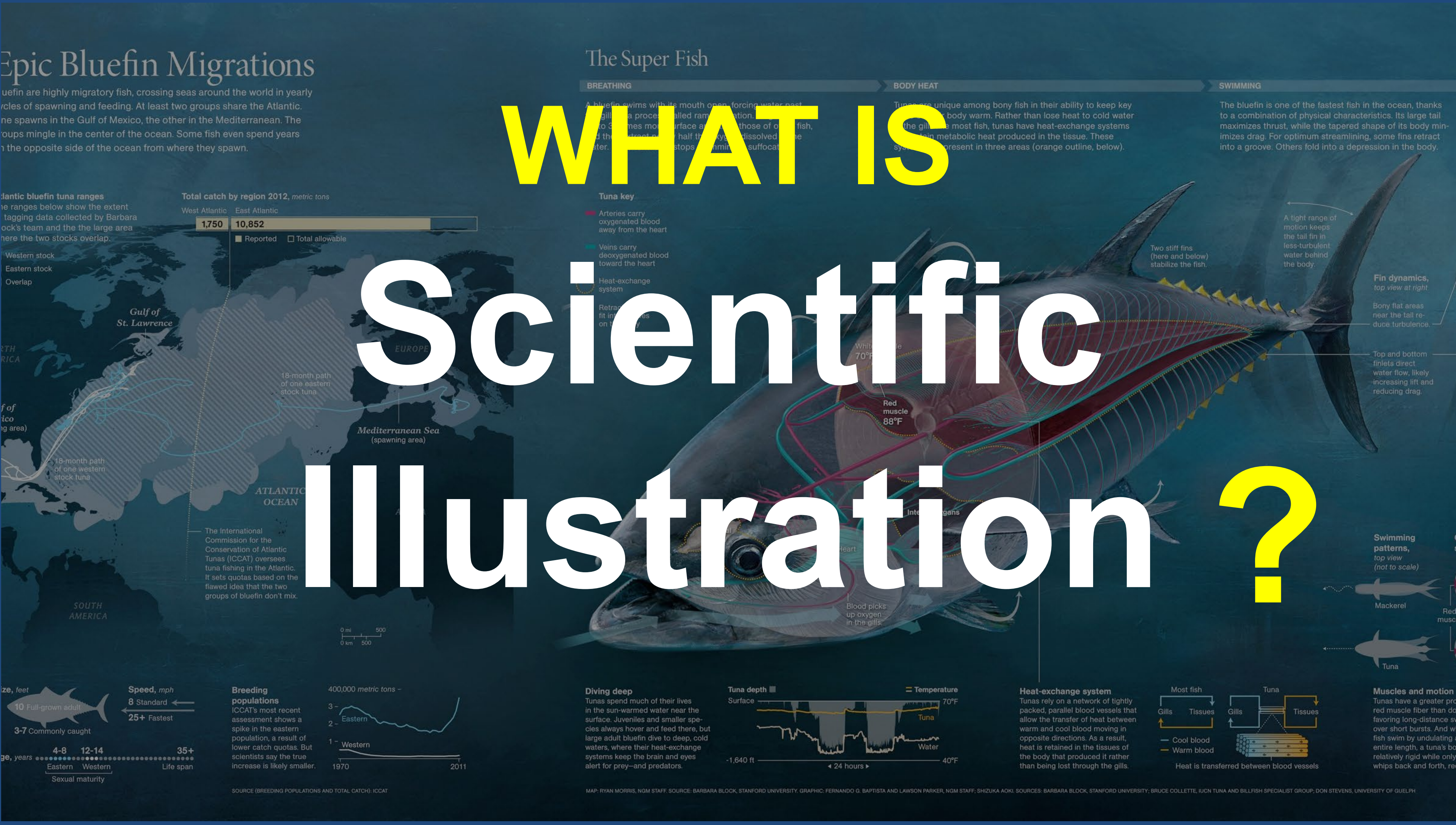
1866-1943



Beatrix Potter

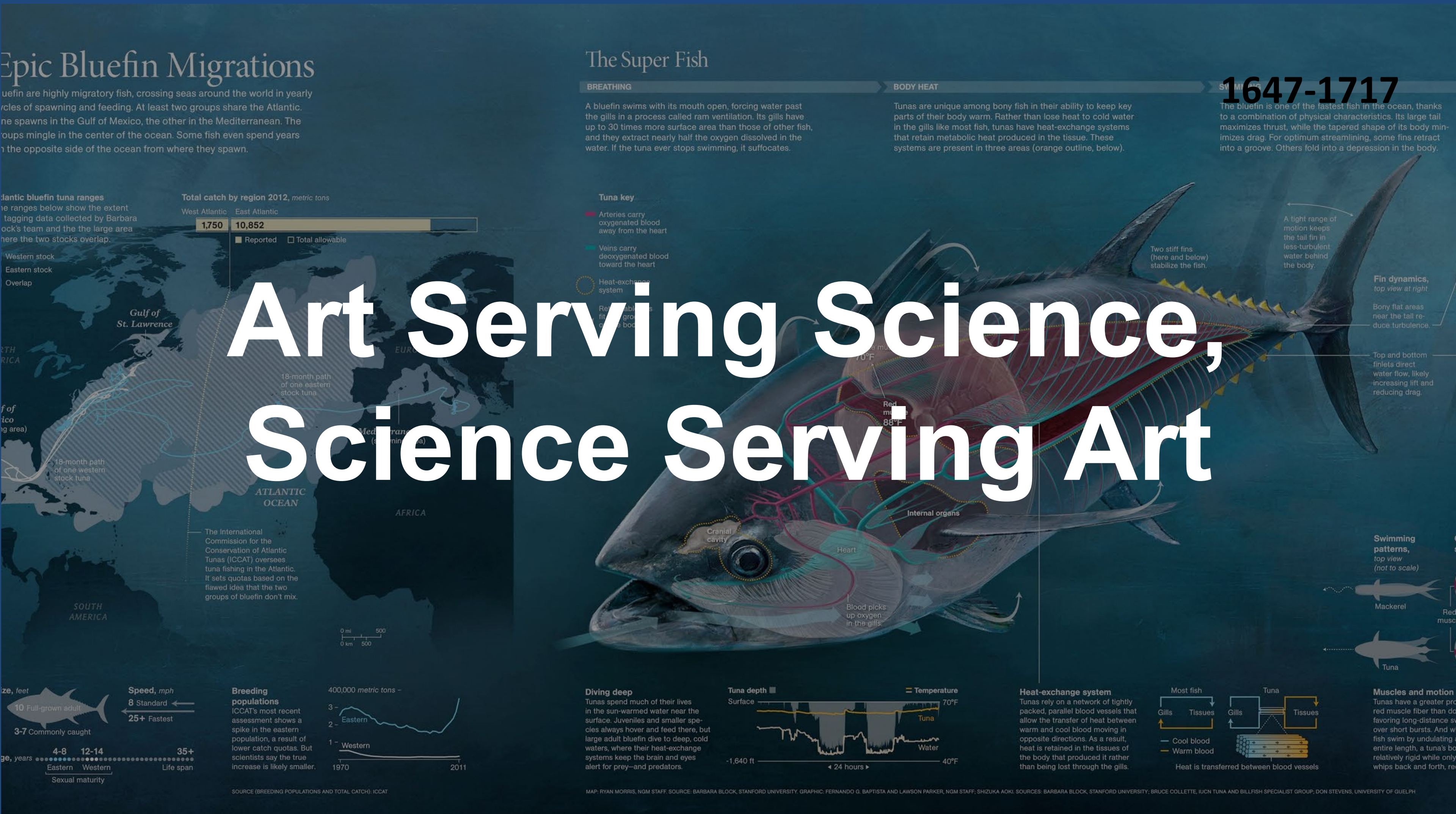
1866-1943

WHAT IS Scientific Illustration ?

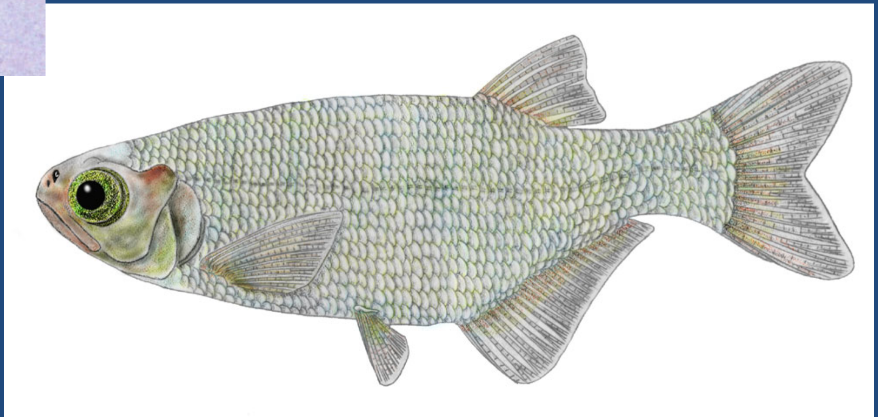


1647-1717

Art Serving Science, Science Serving Art

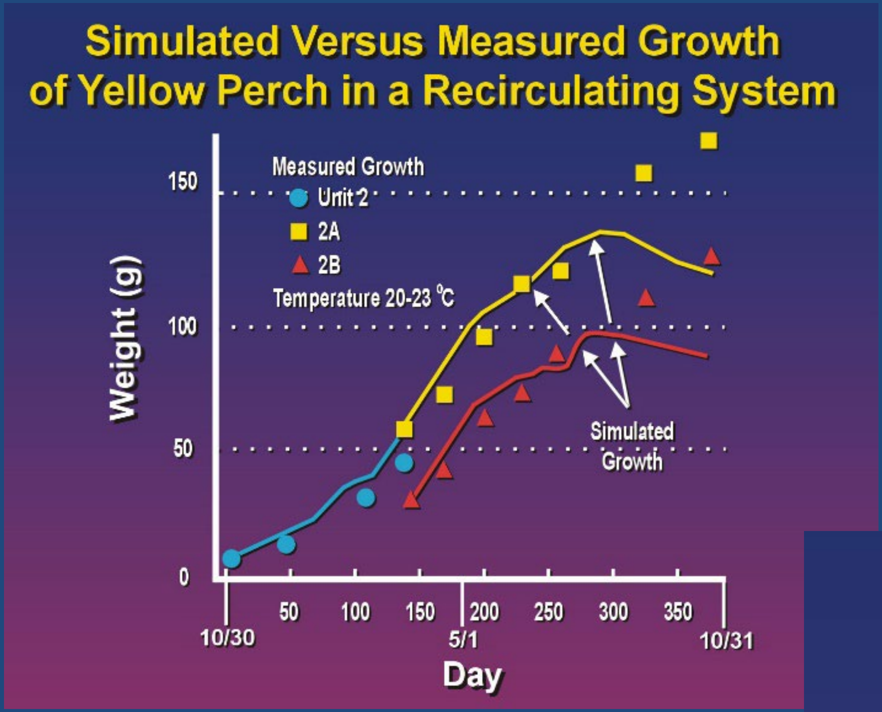


Photography vs. Illustration

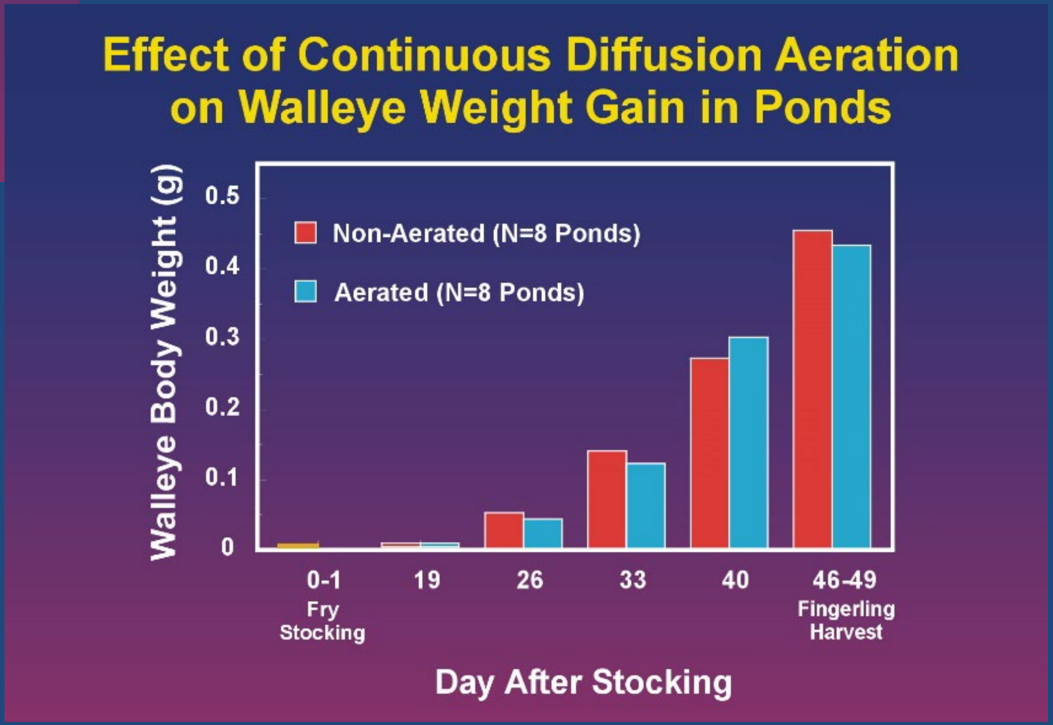


Branches of Science

Technical
Invertebrate Fossils
Anthropology
Diagrams
Ornithology
Vertebrate Fossils
Medical
Wildlife
Archaeology
Paleoanthropology
Botany
Astronomy
Entomology
Map Making
Mammals
Veterinary
Geology
Paleobotany
Cartography
Herpetology
Invertebrates
Charts & Graphs
Icthyology

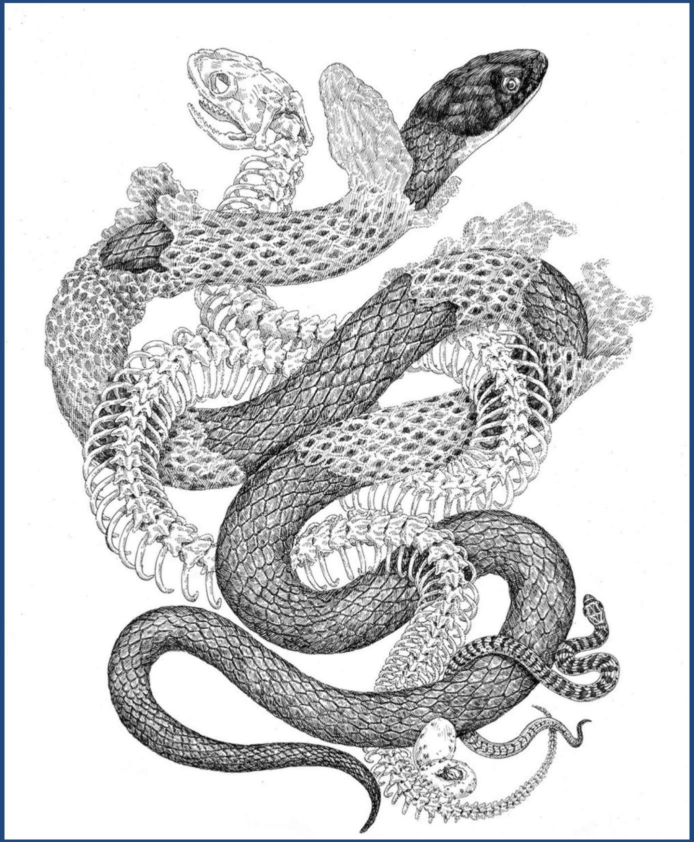
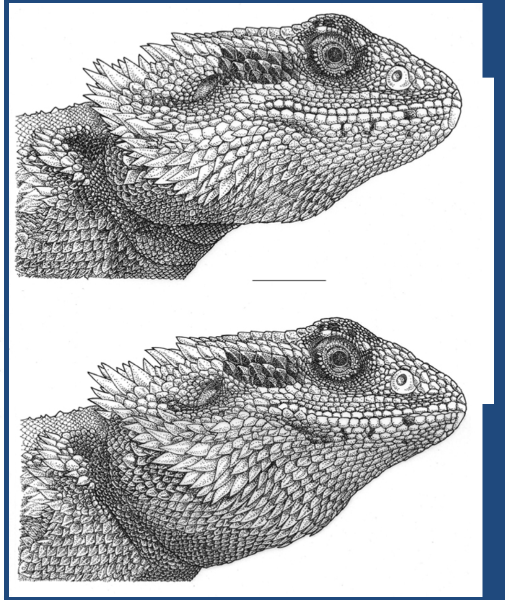
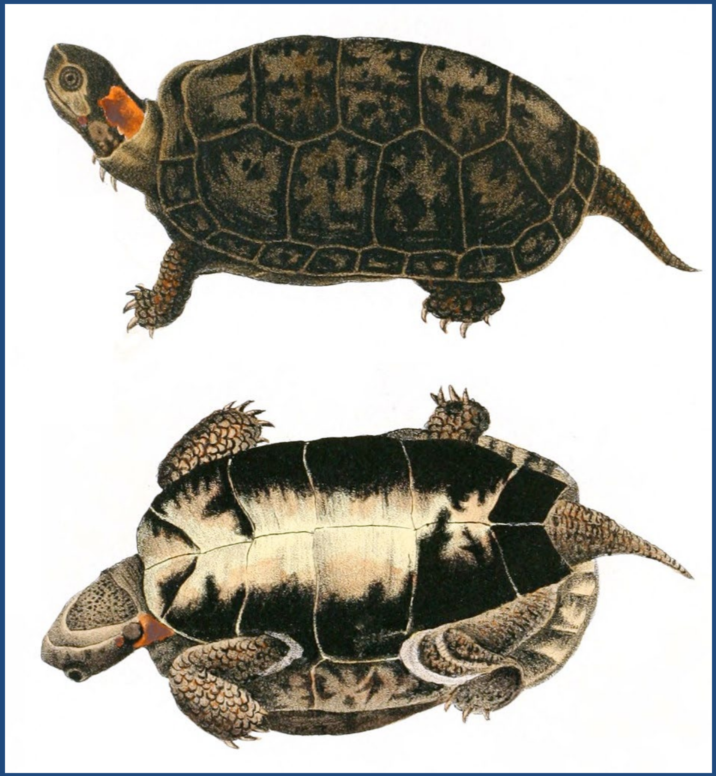


Simulated Versus Measured Growth of Yellow Perch in a Recirculating System
Measured Growth
Unit 2
2A
2B
Temperature 20-23 °C
Simulated Growth
Weight (g)
150
100
50
0
50
100
150
200
250
300
350
10/30
5/1
10/31
Day

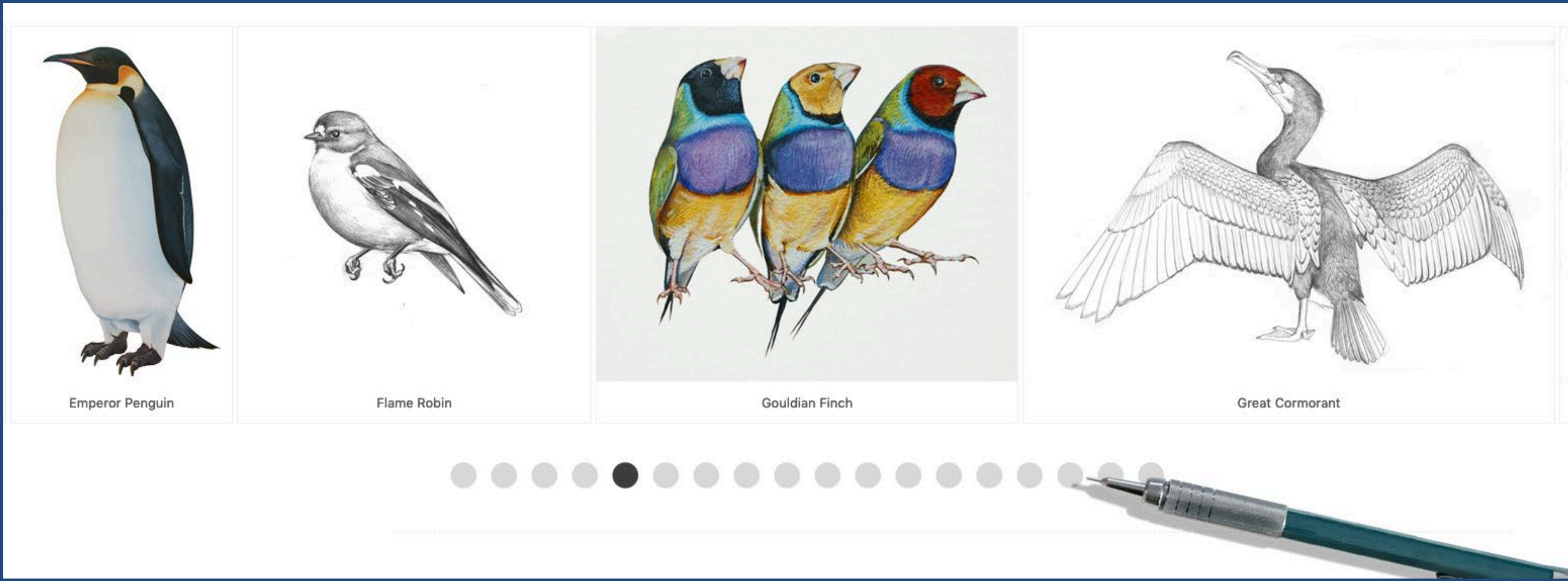


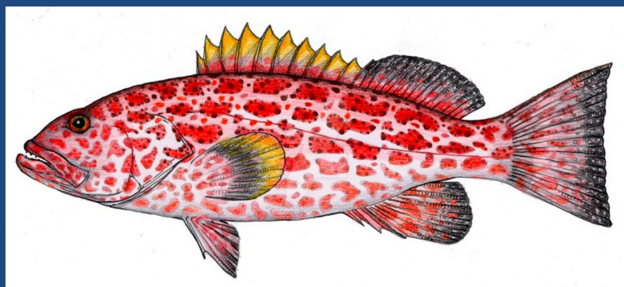
Effect of Continuous Diffusion Aeration on Walleye Weight Gain in Ponds
Non-Aerated (N=8 Ponds)
Aerated (N=8 Ponds)
Walleye Body Weight (g)
0.5
0.4
0.3
0.2
0.1
0
0-1
Fry
Stocking
19
26
33
40
46-49
Fingerling
Harvest
Day After Stocking

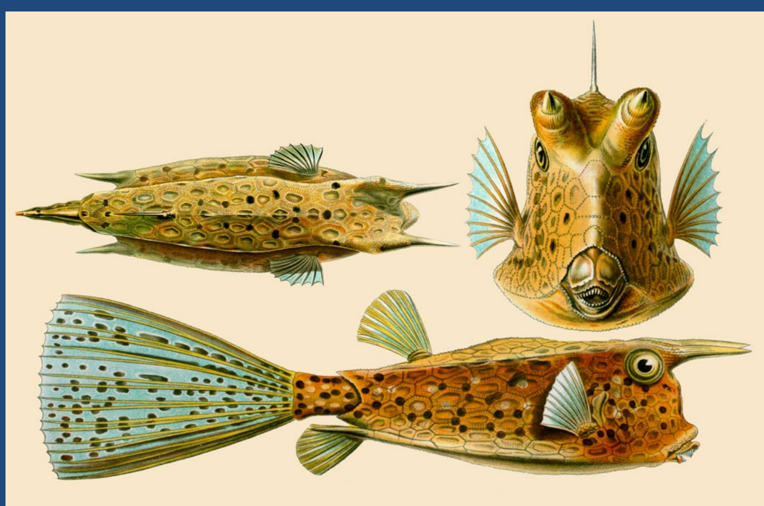
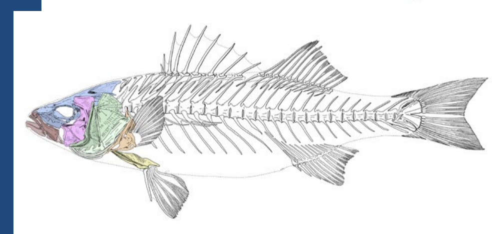
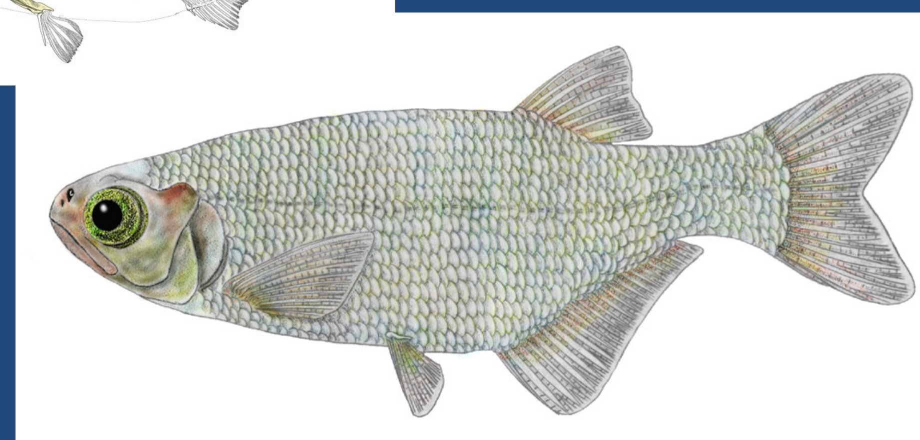
John Cody

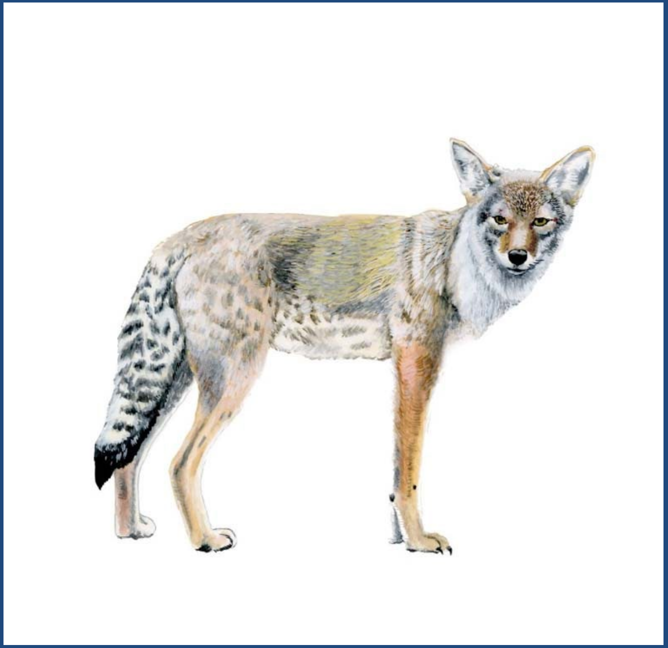




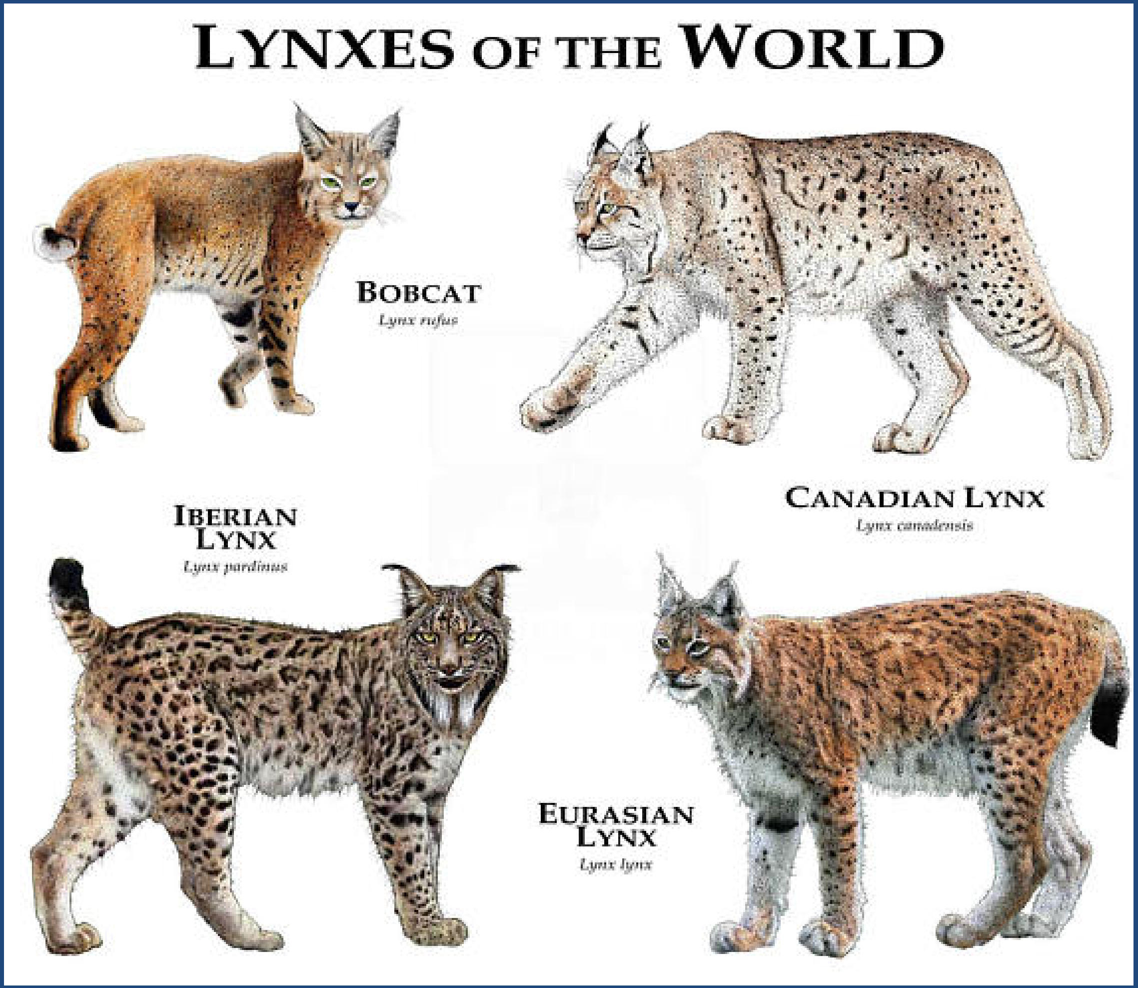
Wall of Birds – The Cornell Lab








LYNXES OF THE WORLD
BOBCAT
Lynx rufus
CANADIAN LYNX
Lynx canadensis
IBERIAN LYNX
Lynx pardinus
EURASIAN LYNX
Lynx lynx

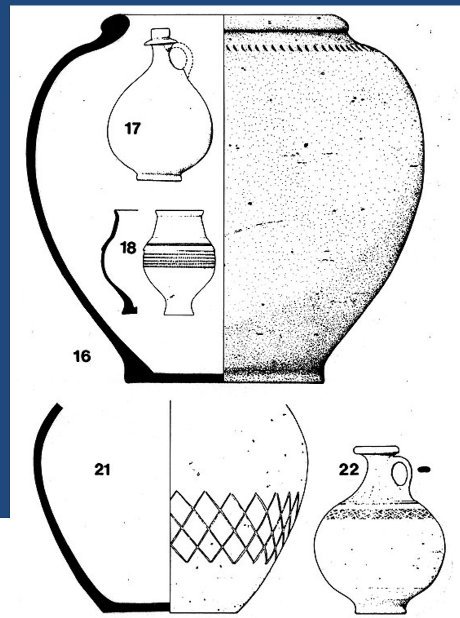
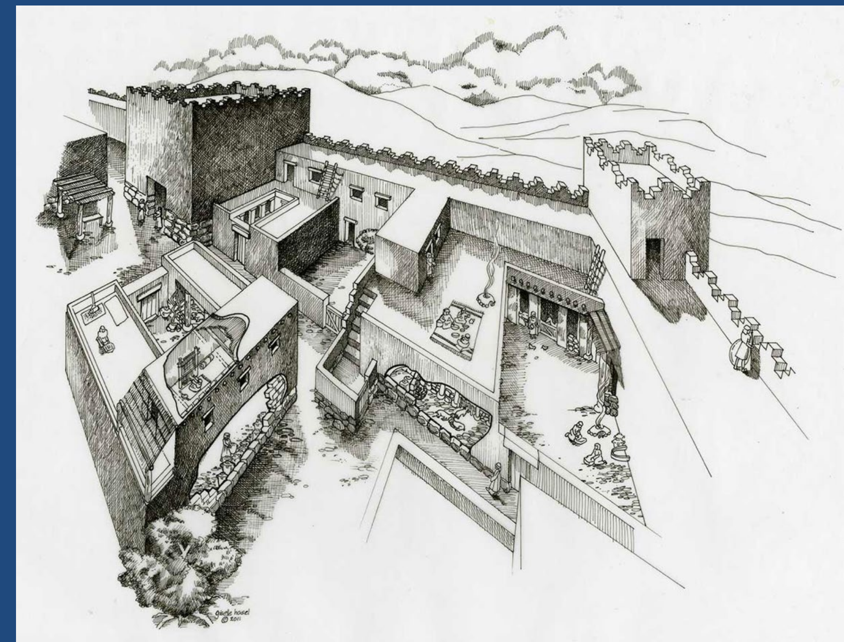
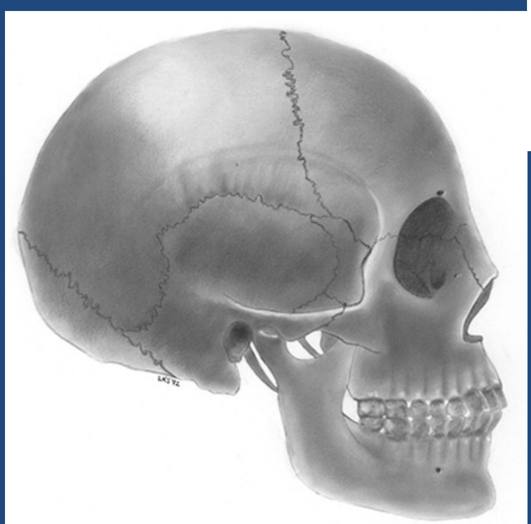
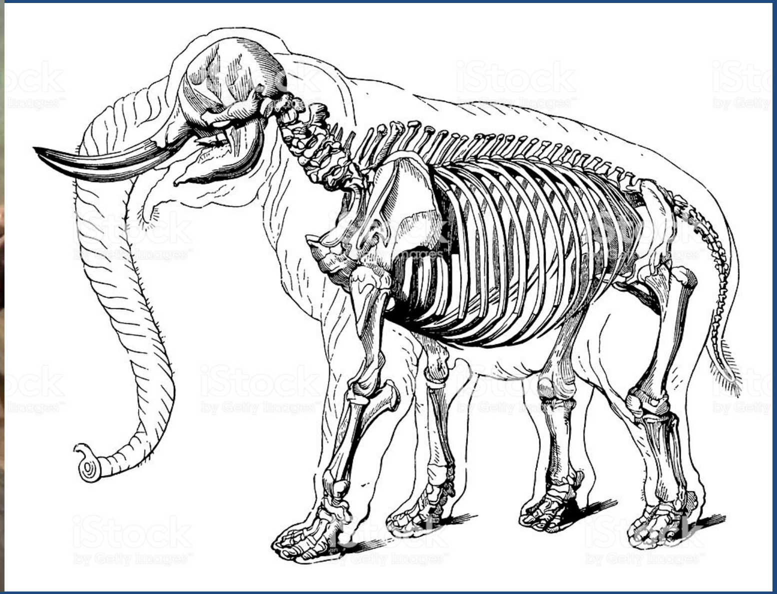
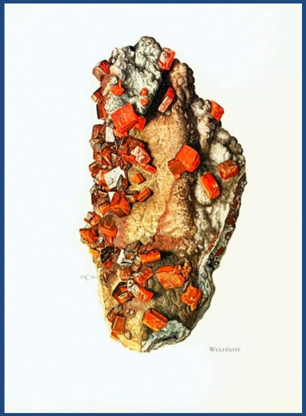


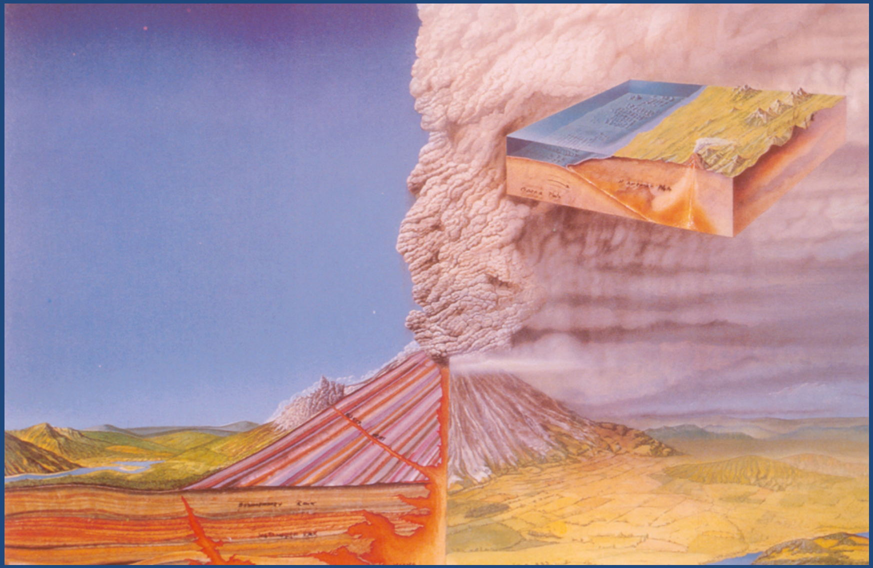
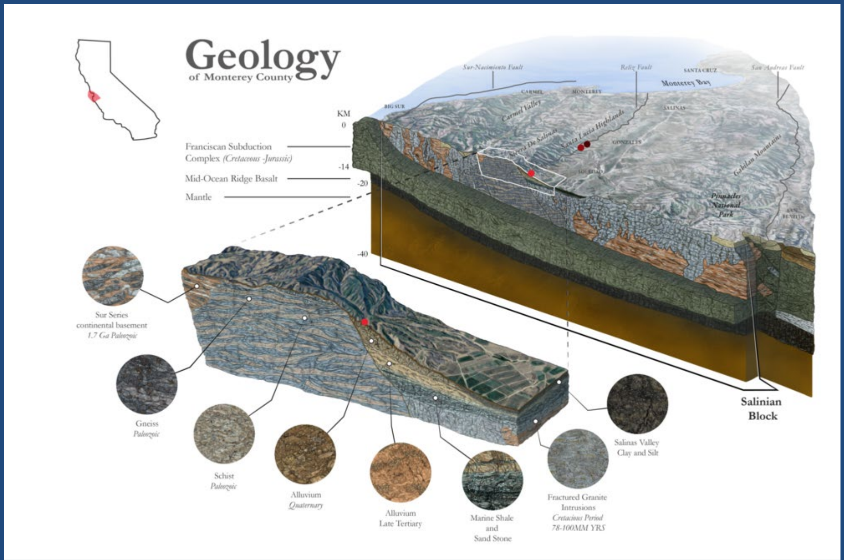
Fig. 6. Northbourne Roman Cemetery. Objects from the Burials.
Burial 7 (Nos.16–18); Burial 9 (Nos.19 & 20); Burial 10 (Nos.21 & 22)

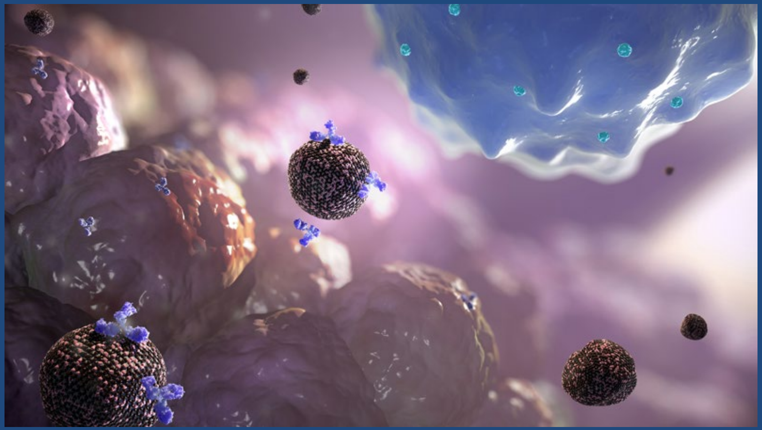


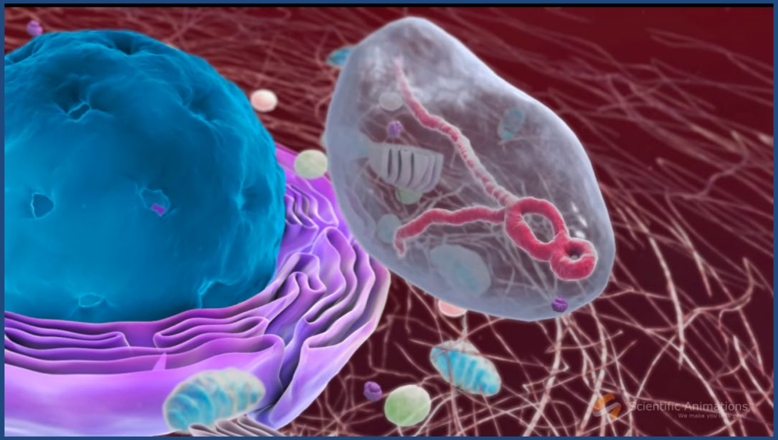




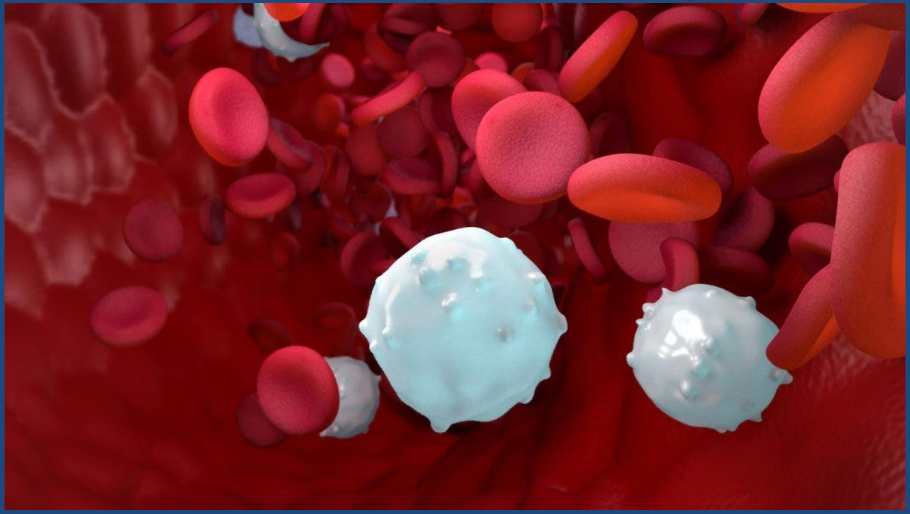



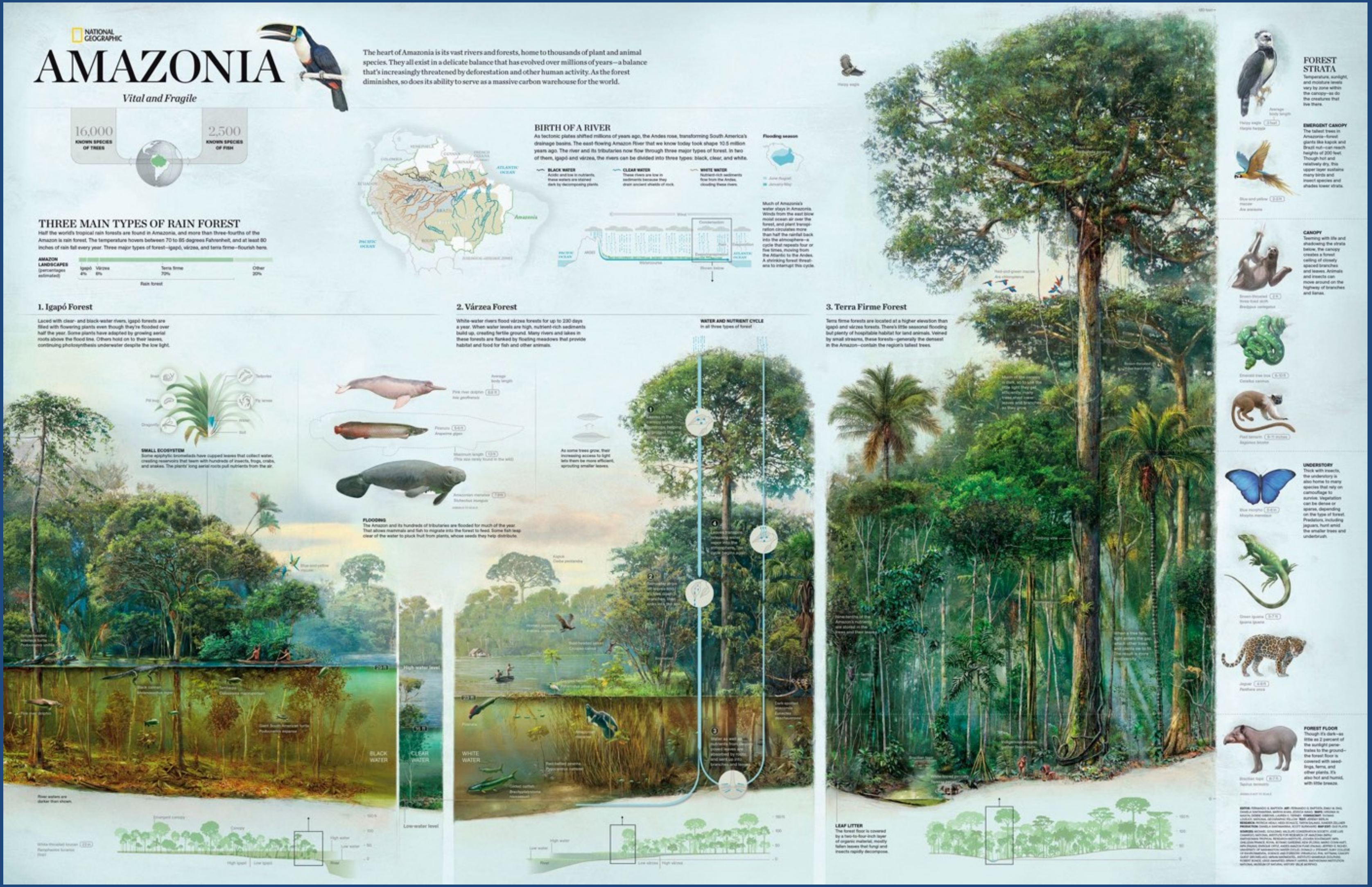


Geology
of Monterey County
Sur-Nacimiento Fault
Reliz Fault
SANTA CRUZ
San Andreas Fault
Monterey Bay
CARMEL
MONTEREY
BIG SUR
Carmel Valley
SALINAS
Santa Lucia Highlands
Sierra De Salinas
GONZALES
SOLEDAD
Gabilan Mountains
Pinnacles National Park
KM
0
-14
-20
-40
Franciscan Subduction Complex (Cretaceous -Jurassic)
Mid-Ocean Ridge Basalt
Mantle
Sur Series continental basement 1.7 Ga Paleozoic
Gneiss Paleozoic
Schist Paleozoic
Alluvium Quaternary
Alluvium Late Tertiary
Marine Shale and Sand Stone
Fractured Granite Intrusions Cretacious Period 78-100MM YRS
Salinas Valley Clay and Silt
Salinian Block

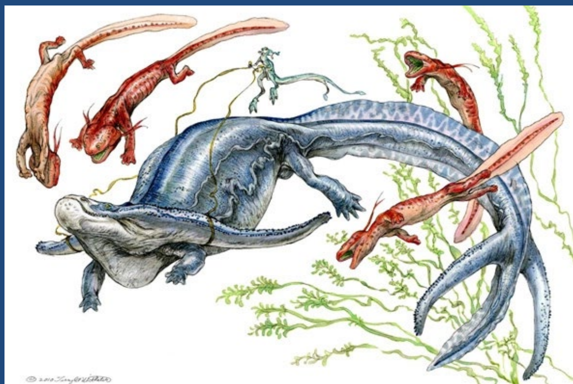


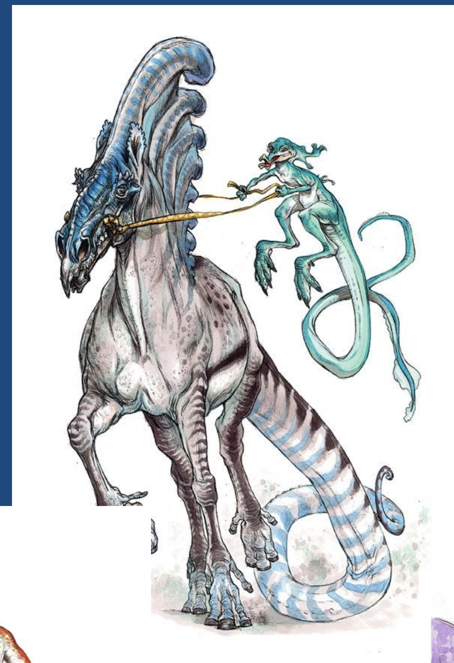


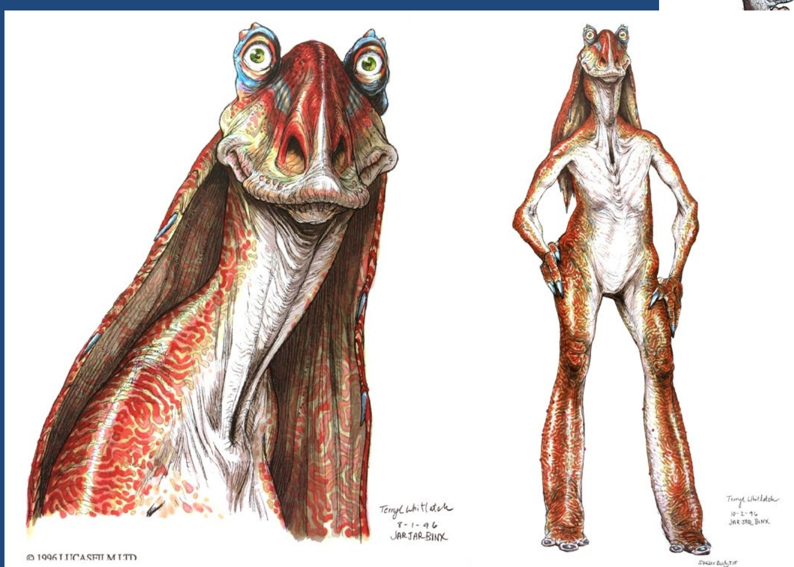
Scientific Animations



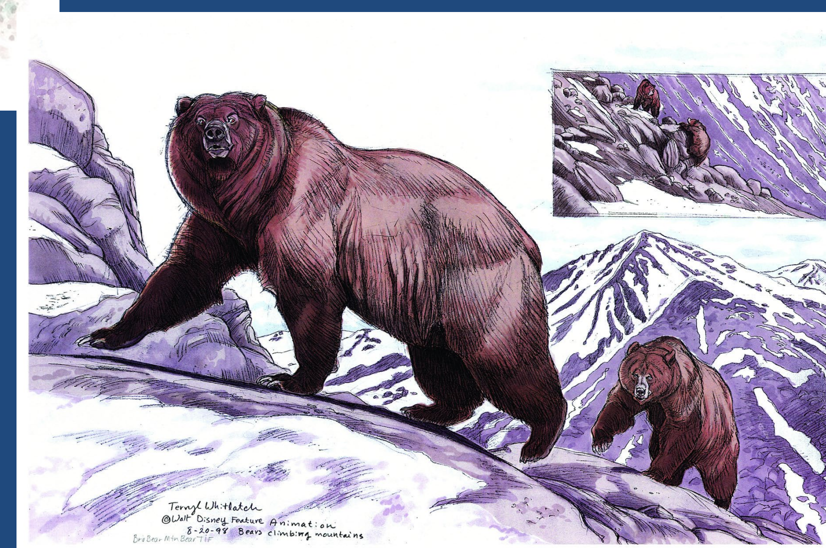

NATIONAL GEOGRAPHIC
AMAZONIA
Vital and Fragile
The heart of Amazonia is its vast rivers and forests, home to thousands of plant and animal species. They all exist in a delicate balance that has evolved over millions of years—a balance that's increasingly threatened by deforestation and other human activity. As the forest diminishes, so does its ability to serve as a massive carbon warehouse for the world.
16,000 KNOWN SPECIES OF TREES
2,500 KNOWN SPECIES OF FISH
BIRTH OF A RIVER
As tectonic plates shifted millions of years ago, the Andes rose, transforming South America's drainage basins. The east-flowing Amazon River that we know today took shape 10.5 million years ago. The river and its tributaries now flow through three major types of forest. In two of them, igapó and várzea, the rivers can be divided into three types: black, clear, and white.
BLACK WATER
Acidic and low in nutrients, these waters are stained dark by decomposing plants.
CLEAR WATER
These rivers are low in sediments because they drain ancient shields of rock.
WHITE WATER
Nutrient-rich sediments flow from the Andes, clouding these rivers.
Flooding season
ATLANTIC OCEAN
PACIFIC OCEAN
Amazonia
Much of Amazonia's water stays in Amazonia. Winds from the east blow moist ocean air over the forest, and plant transpiration circulates more than half the rainfall back into the atmosphere—a cycle that repeats four or five times, moving from the Atlantic to the Andes. A shrinking forest threatens to interrupt this cycle.
THREE MAIN TYPES OF RAIN FOREST
Half the world's tropical rain forests are found in Amazonia, and more than three-fourths of the Amazon is rain forest. The temperature hovers between 70 to 85 degrees Fahrenheit, and at least 80 inches of rain fall every year. Three major types of forest—igapó, várzea, and terra firme—flourish here.
AMAZON LANDSCAPES (percentages estimated)
Igapó 4%
Várzea 6%
Terra firme 70%
Other 20%
Rain forest
1. Igapó Forest
Laced with clear- and black-water rivers, igapó forests are filled with flowering plants even though they're flooded over half the year. Some plants have adapted by growing aerial roots above the flood line. Others hold on to their leaves, continuing photosynthesis underwater despite the low light.
2. Várzea Forest
White-water rivers flood várzea forests for up to 230 days a year. When water levels are high, nutrient-rich sediments build up, creating fertile ground. Many rivers and lakes in these forests are flanked by floating meadows that provide habitat and food for fish and other animals.
WATER AND NUTRIENT CYCLE
In all three types of forest
3. Terra Firme Forest
Terra firme forests are located at a higher elevation than igapó and várzea forests. There's little seasonal flooding but plenty of hospitable habitat for land animals. Veined by small streams, these forests—generally the densest in the Amazon—contain the region's tallest trees.
BLACK WATER
CLEAR WATER
WHITE WATER
High-water level
Low-water level
FOREST STRATA
Temperature, sunlight, and moisture levels vary by zone within the canopy—as do the creatures that live there.
EMERGENT CANOPY
The tallest trees in Amazonia—forest giants like kapok and Brazil nut—can reach heights of 200 feet. Though hot and relatively dry, this upper layer sustains many birds and insect species and shades lower strata.
CANOPY
Teeming with life and shadowing the strata below, the canopy creates a forest ceiling of closely spaced branches and leaves. Animals and insects can move around on the highway of branches and lianas.
UNDERSTORY
Thick with insects, the understory is also home to many species that rely on camouflage to survive. Vegetation can be dense or sparse, depending on the type of forest. Predators, including jaguars, hunt amid the smaller trees and underbrush.
FOREST FLOOR
Though it's dark—as little as 2 percent of the sunlight penetrates to the ground—the forest floor is covered with seedlings, ferns, and other plants. It's also hot and humid, with little breeze.







Terryl Anne Whitlatch



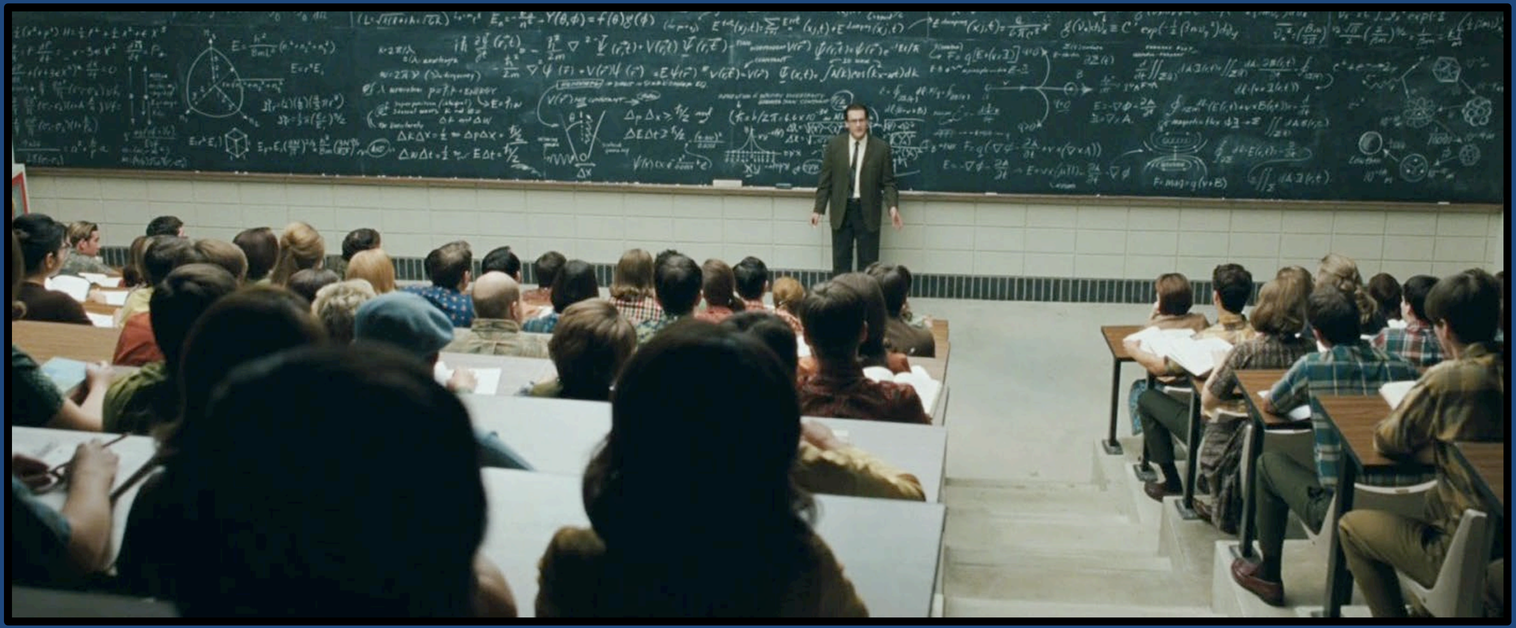
How my interest in art has changed the way I teach science

Early Classroom Frustrations

- Lack of active learning
- Lost students in labs

Some Core Concepts that can be addressed by illustration

- **Create an active learning environment –**



bestwallpapers.com

Why is active learning so important?

- "Active learning increases student performance in science, engineering, and mathematics" - Freeman et al. 2013
  - Students in traditional lecture classes 1.5 times more likely to fail than classes with active learning

Drawing is Active Learning
… but in a special way

- Direct activation of previously stored concepts facilitates comprehension and further activates stored knowledge to support inferencing processes
  – Graesser and Goodman 1985

http://notadamandsteve.com

Why Drawing Works

- Students have information, but it does not automatically produce useful knowledge
- Something must change in the brain to create true understanding
- True ownership of knowledge: change in the learner from a receiver to a producer –Zull 2002
- Changing data to knowing is a “transformation experience” - Klob 1984

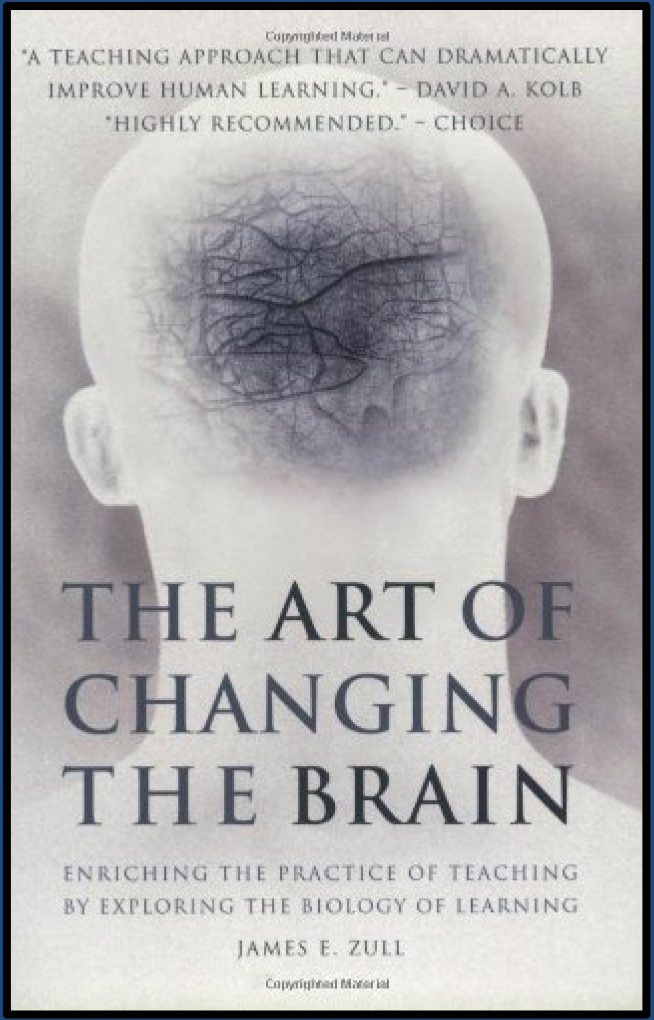
Drawing is Transformative!

- **Whole brain engagement**
  - **Sensory cortex:** vision, hearing , touch, smells, taste
  - **Back integrative cortex:** integrates sensory information to create images and meaning
  - **Frontal integrative cortex:** memory recall and organizing actions and activities of the body
  - **Motor cortex:** triggers coordinated and voluntary muscle contractions in the body (speech, writing, drawing)

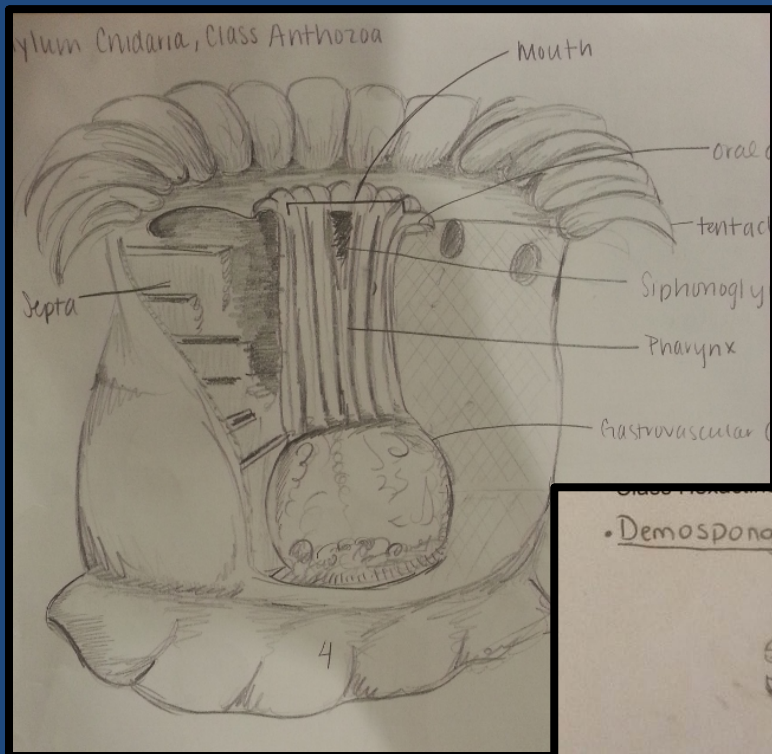
–Zull 2002

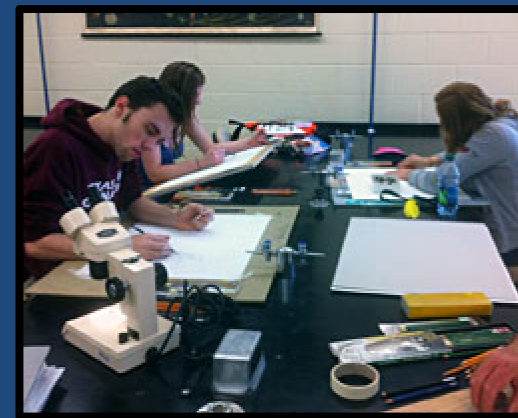
Zull's Proposals for Deeper Learning

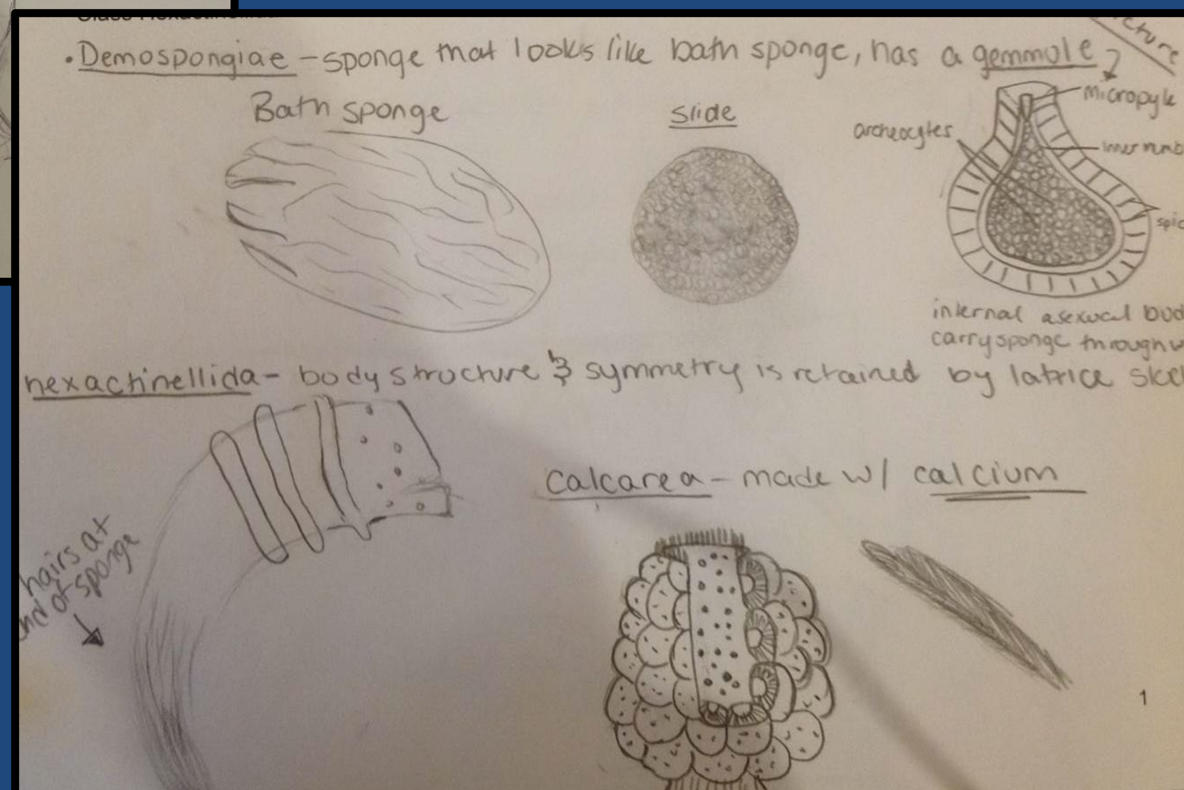
- Assignments given to intentionally integrate experience and memory through reflection
- Insist that students develop their own abstract ideas and explanation (use integrative frontal cortex)
- Bring in the motor brain. Insist that students actively demonstrate their ideas
- Make <u>ALL</u> learning experiential

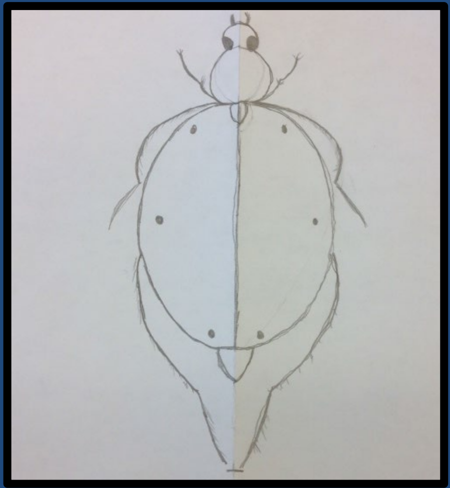
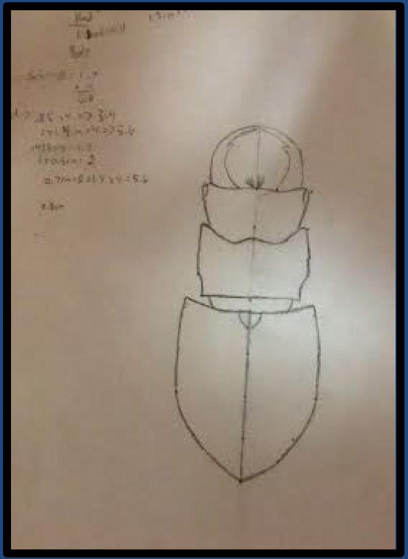


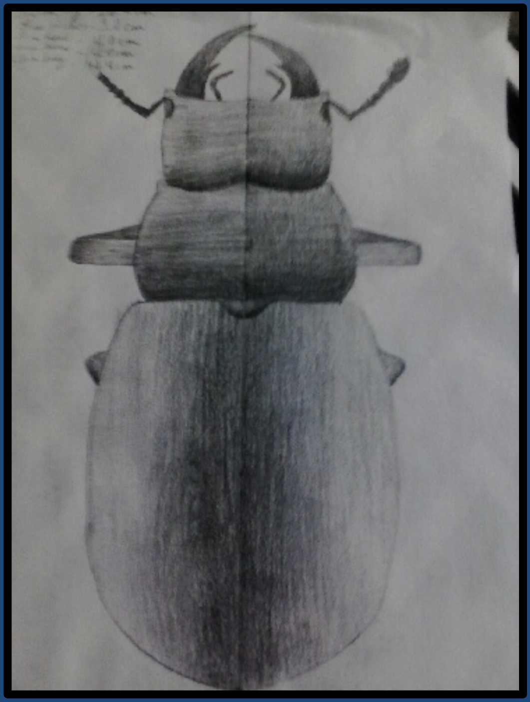
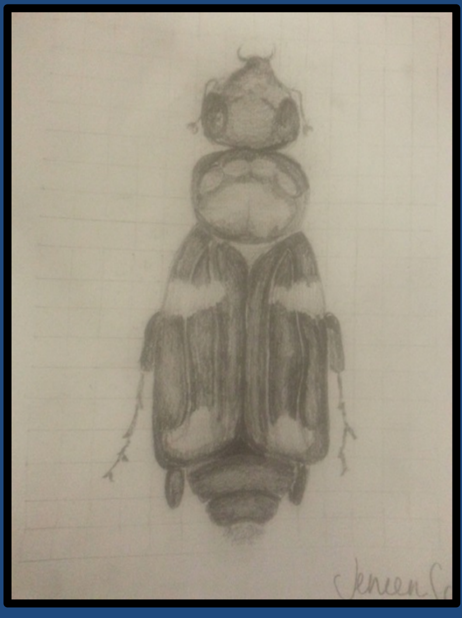
–Zull 2002

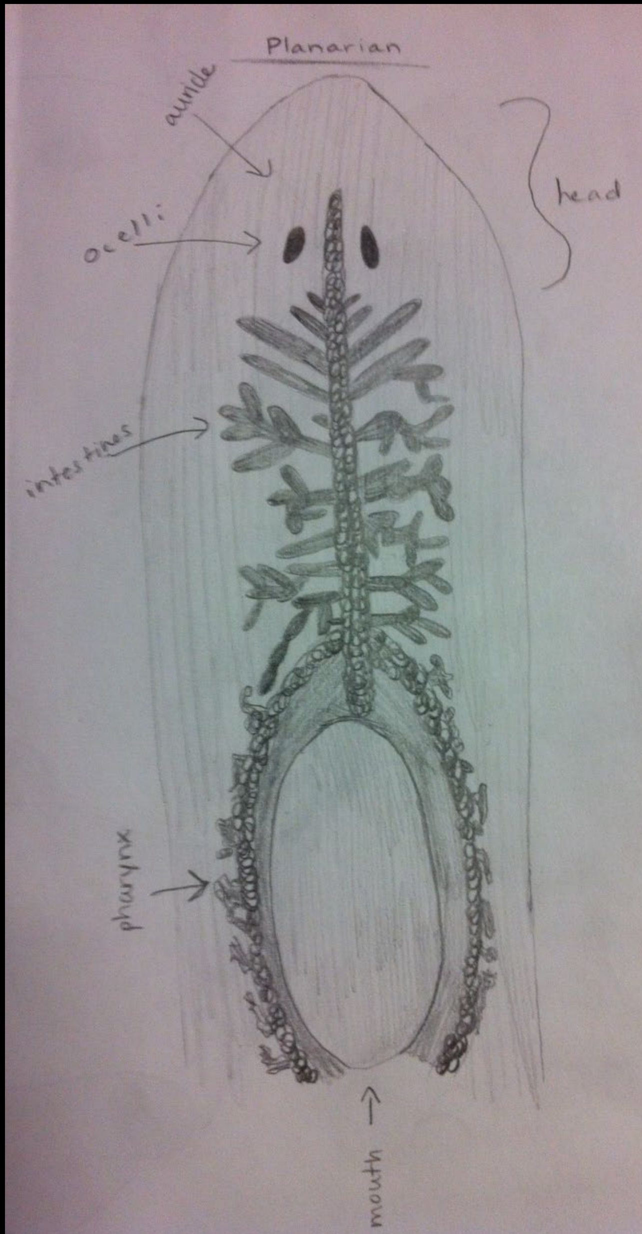

ylum Cnidaria, Class Anthozoa
Mouth
Oral
tentac
Siphonogly
Pharynx
Gastrovascular
Septa
4

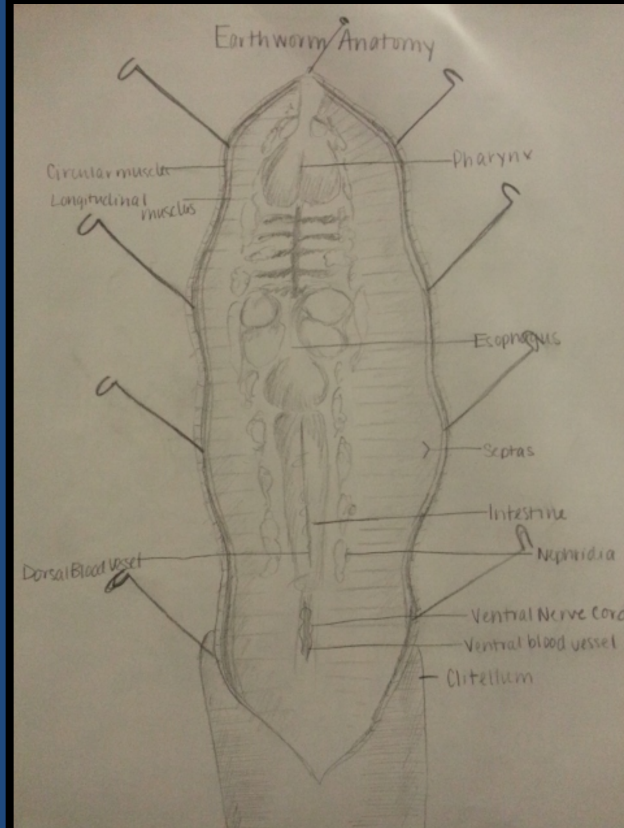


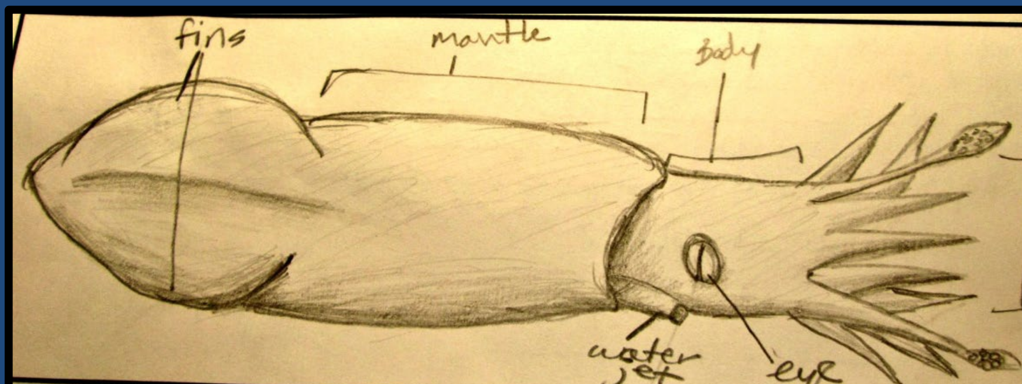

• Demospongiae - sponge that looks like bath sponge, has a gemmule
Bath sponge
slide
Micropyle
archeocytes
internal asexual bud
carry sponge through
hexactinellida - body structure & symmetry is retained by latrice skel
Calcarea - made w/ calcium
hairs at end of sponge
1

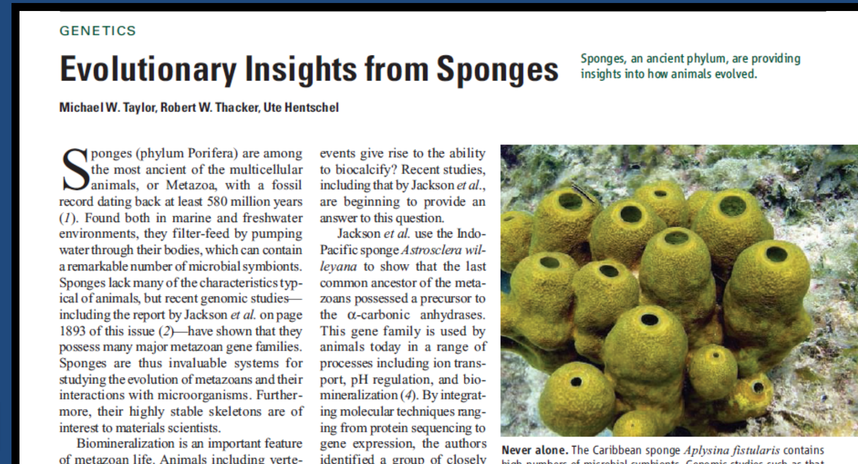

Planarian
auricle
head
ocelli:
intestines
pharynx
mouth


Earthworm Anatomy
Circular muscle
Longitudinal muscles
Pharynx
Esophagus
Septas
Intestine
Nephridia
Dorsal Blood Vessel
Ventral Nerve Cord
Ventral blood vessel
Clitellum


fins
mantle
Body
water jet
eye

Example Prompts

- **Illustrate a food particle being taken up in each major sponge body form. Depict how sponge size is related to surface area and therefor sponge form.**



GENETICS

Evolutionary Insights from Sponges

Sponges, an ancient phylum, are providing insights into how animals evolved.

Michael W. Taylor, Robert W. Thacker, Ute Hentschel

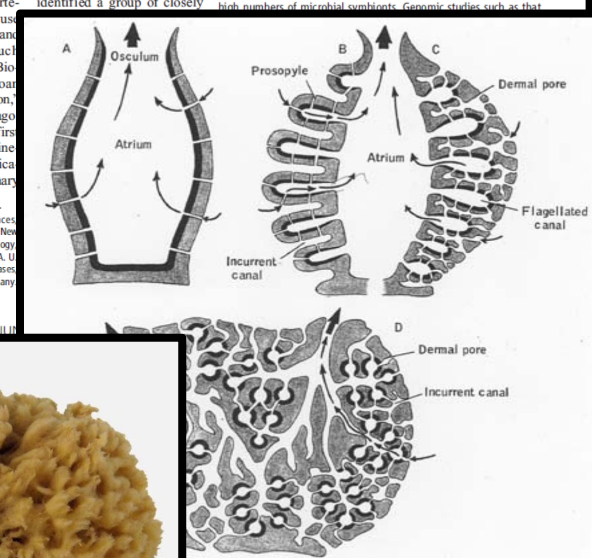
Sponges (phylum Porifera) are among the most ancient of the multicellular animals, or Metazoa, with a fossil record dating back at least 580 million years (*1*). Found both in marine and freshwater environments, they filter-feed by pumping water through their bodies, which can contain a remarkable number of microbial symbionts. Sponges lack many of the characteristics typical of animals, but recent genomic studies—including the report by Jackson *et al.* on page 1893 of this issue (*2*)—have shown that they possess many major metazoan gene families. Sponges are thus invaluable systems for studying the evolution of metazoans and their interactions with microorganisms. Furthermore, their highly stable skeletons are of interest to materials scientists.

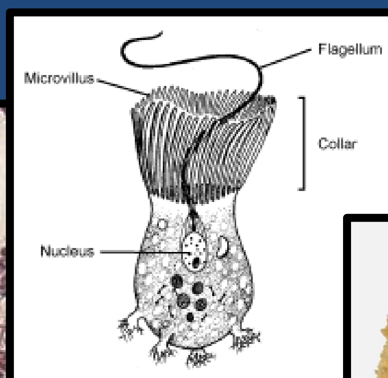
Biomineralization is an important feature of metazoan life. Animals including vertebrates, insects, mollusks, and sponges use minerals [such as calcium carbonate, iron, and silica] to form skeletal structures such as bones, seashells, and coral reefs (*3*). Biocalcification arose among many metazoan lineages during the "Cambrian explosion," between 530 and 520 million years ago when the ancestors of today's animals first appeared in the fossil record. Did these lineages share the same gene(s) for biocalcification, or did multiple independent evolutionary events give rise to the ability to biocalcify? Recent studies, including that by Jackson *et al.*, are beginning to provide an answer to this question.

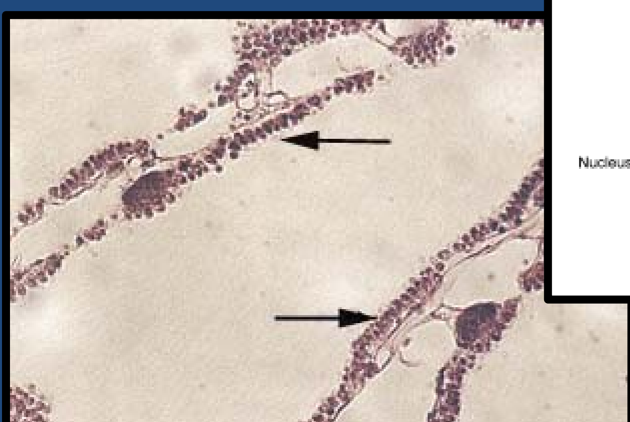
Jackson *et al.* use the Indo-Pacific sponge *Astrosclera willeyana* to show that the last common ancestor of the metazoans possessed a precursor to the α-carbonic anhydrases. This gene family is used by animals today in a range of processes including ion transport, pH regulation, and biomineralization (*4*). By integrating molecular techniques ranging from protein sequencing to gene expression, the authors identified a group of closely

Never alone. The Caribbean sponge *Aplysina fistularis* contains high numbers of microbial symbionts. Genomic studies such as that

M. W. Taylor is in the School of Biological Sciences, University of Auckland, Private Bag 92019, Auckland, New Zealand. R. W. Thacker is in the Department of Biology, University of Alabama at Birmingham, AL 35294, USA. U. Hentschel is at the Research Center for Infectious Diseases, University of Würzburg, 97070 Würzburg, Germany. E-mail: ute.hentschel@mail.uni-wuerzburg.de

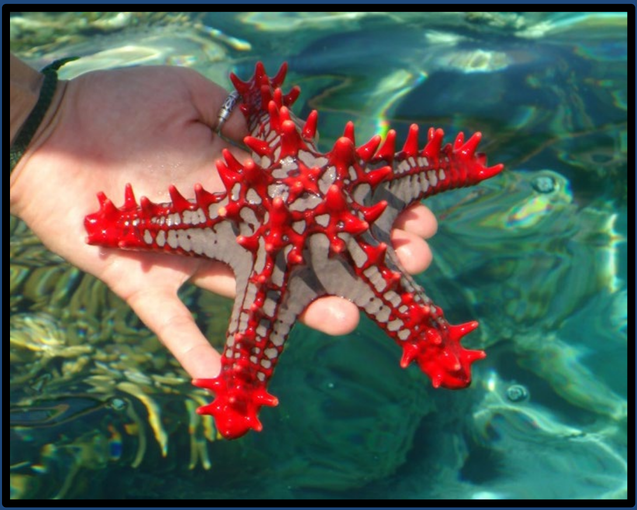


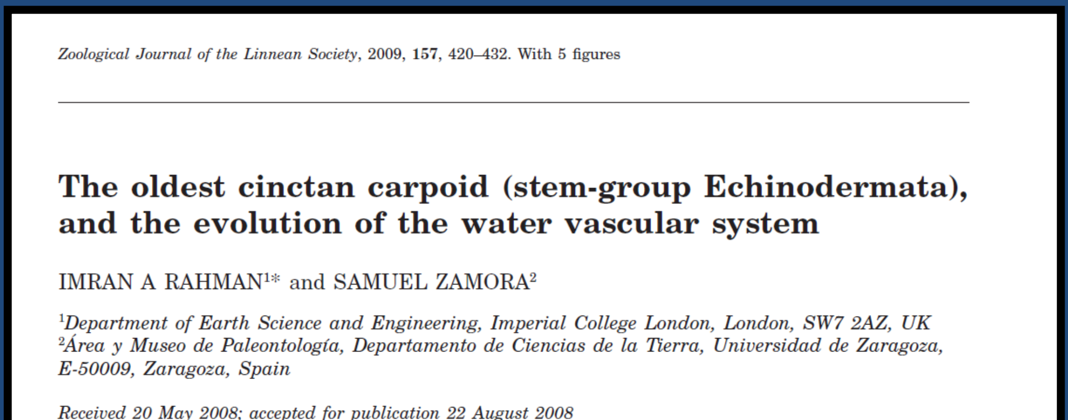




Example Prompts

- **Illustrate the flow of water through the water-vascular system and how it relates to movement in echinoderms.**





Zoological Journal of the Linnean Society, 2009, **157**, 420–432. With 5 figures

The oldest cinctan carpoid (stem-group Echinodermata), and the evolution of the water vascular system

IMRAN A RAHMAN[1]* and SAMUEL ZAMORA[2]

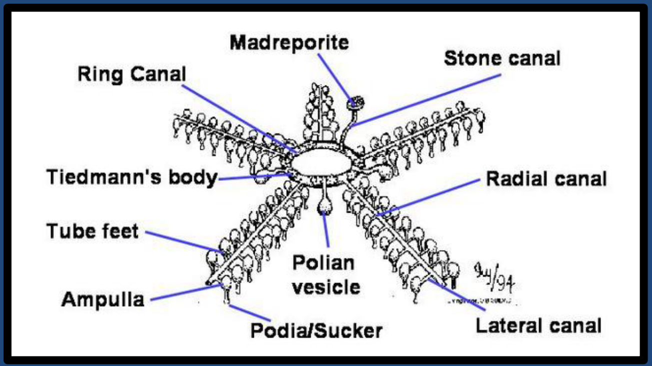
[1]*Department of Earth Science and Engineering, Imperial College London, London, SW7 2AZ, UK*
[2]*Área y Museo de Paleontología, Departamento de Ciencias de la Tierra, Universidad de Zaragoza, E-50009, Zaragoza, Spain*

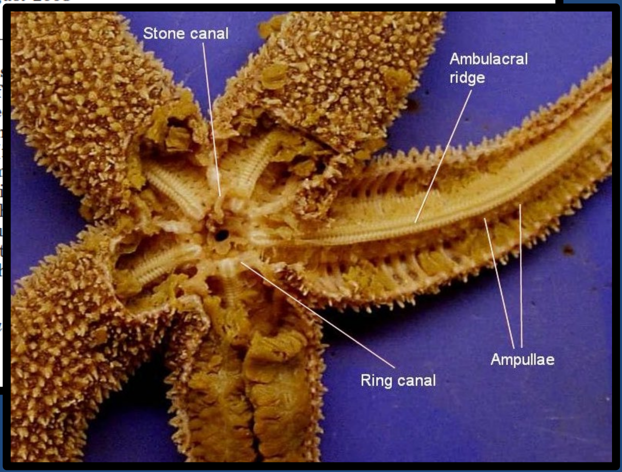
Received 20 May 2008; accepted for publication 22 August 2008

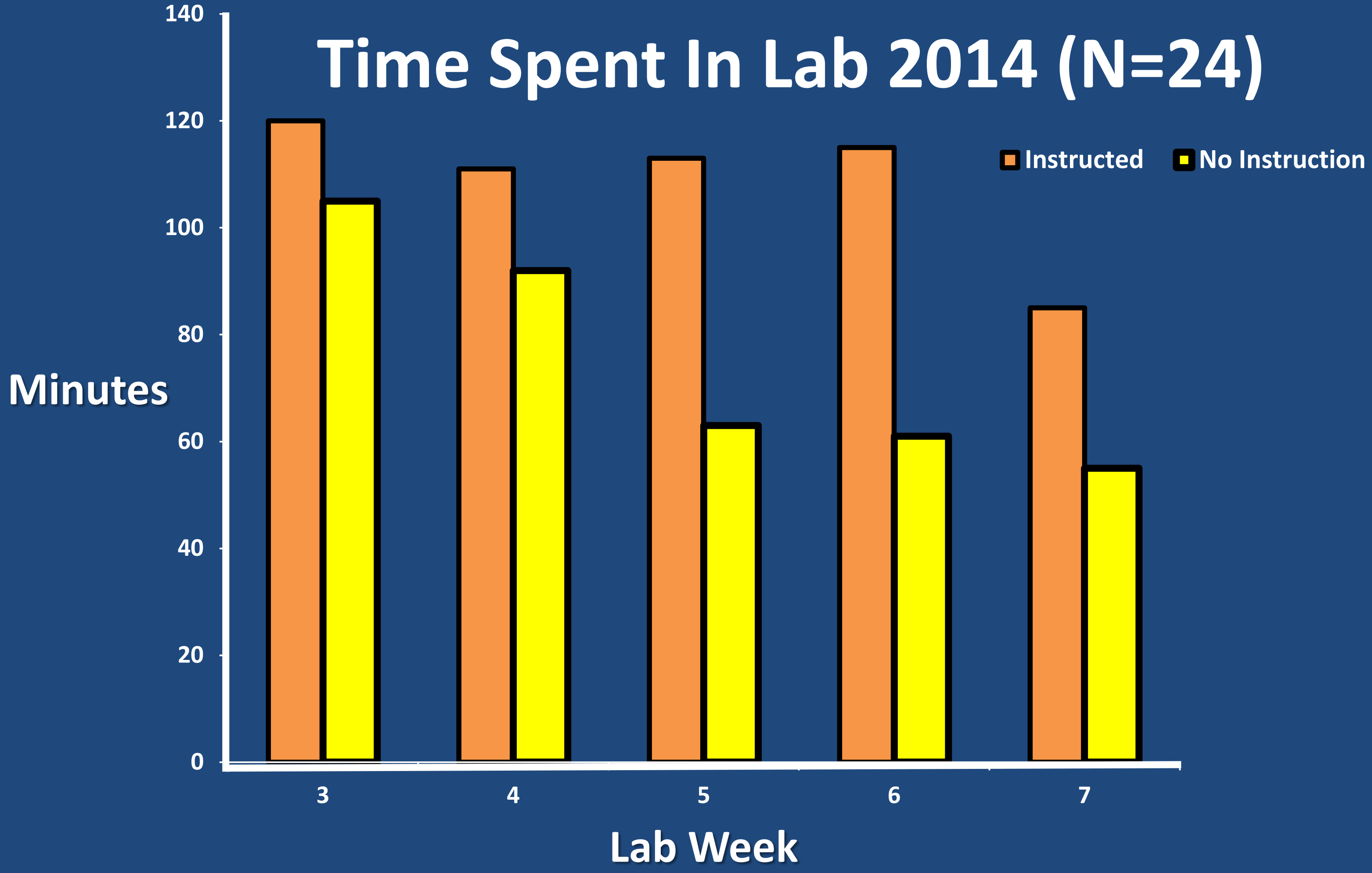
A new cinctan (***Protocinctus mansillaensis* gen. et**
Chains (north-east Spain), is described with the aid of
models. Investigation in this manner was possible be
preserved as recrystallized calcite. ***Protocinctus* gen n**
feeding groove and an open posterior marginal frame (
amongst cinctans. Through the study of original specim
palaeobiology of ***Protocinctus* gen. nov.**: cinctans are
gut, using their posterior appendage to aid stability on t
the evolutionary history of the echinoderm stem grou
vascular system (basal) to one constructed from just
observed in another group of stem-group echinoderms, t
ancestor of the echinoderms and hemichordates.

doi: 10.1111/j.1096-3642.2008.00517.x

ADDITIONAL KEYWORDS: Cambrian – carpoids







Time Spent In Lab 2014 (N=24)
Minutes
140
120
100
80
60
40
20
0
Instructed
No Instruction
3
4
5
6
7
Lab Week

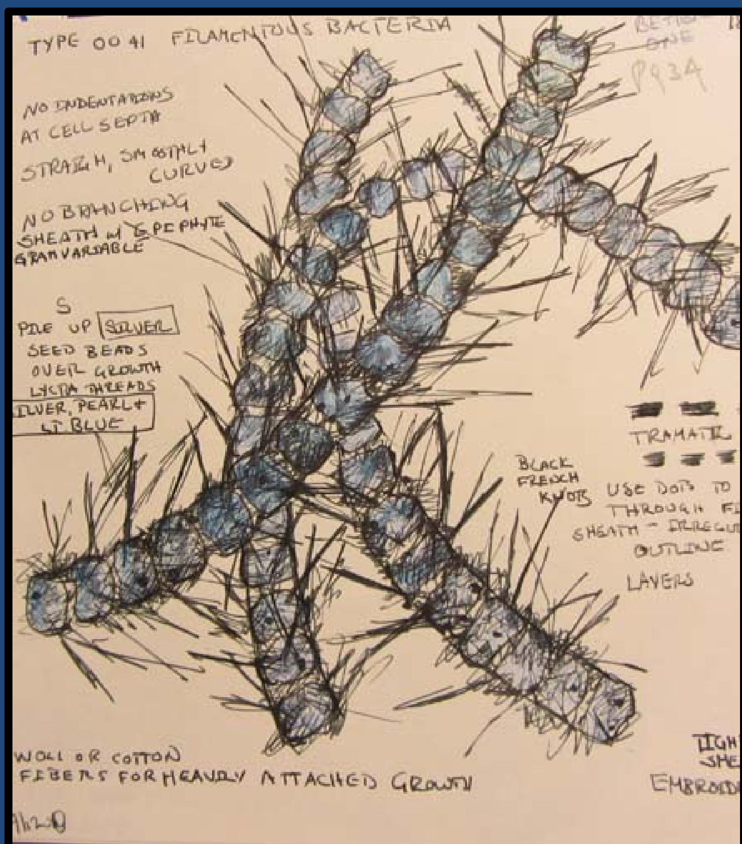
Student Response

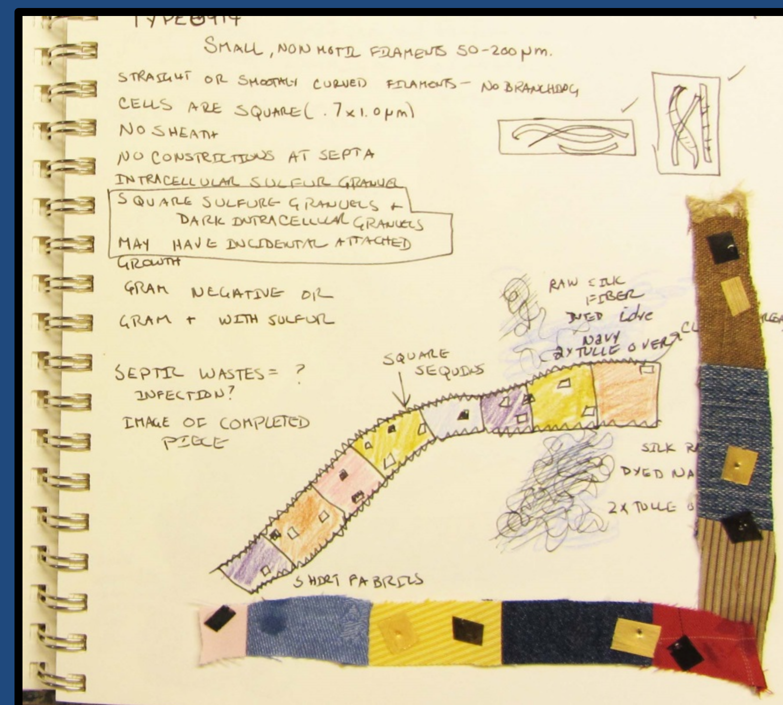
- “It was so much fun to draw things in lab. I still have my beetle hanging up in my room”
- I think that making us draw things helped me learn”
- “Drawing was my favorite part of lab”
- “I didn’t know I could learn to draw”

Future Directions for Research

- **Artist Scientist Partnership: Lindsay Olson**

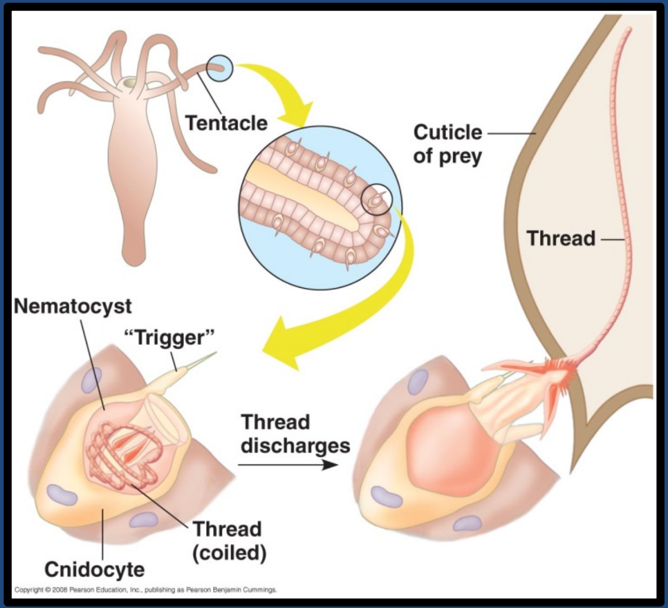
The power of our sketchbooks

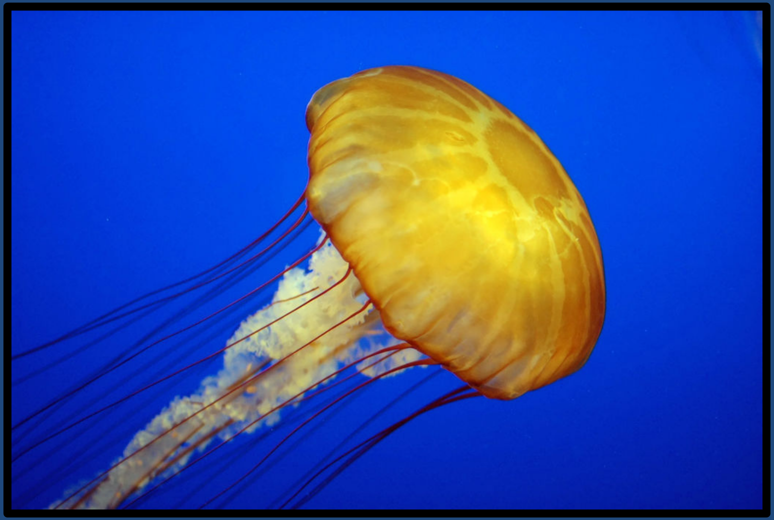




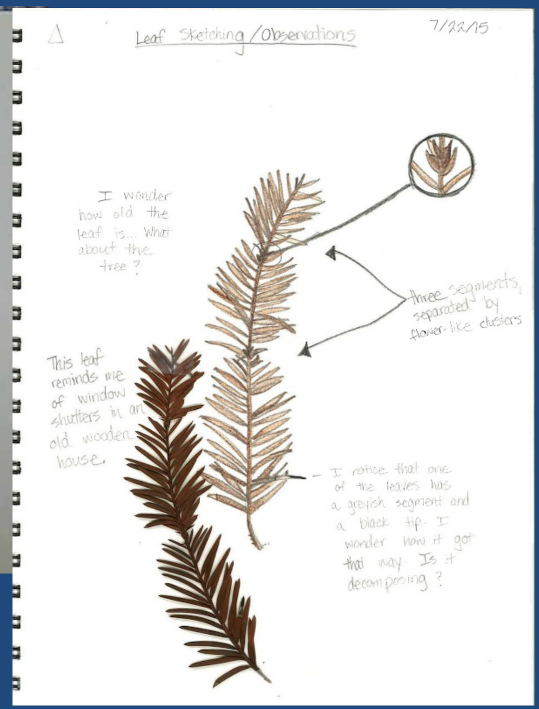
Example Prompts

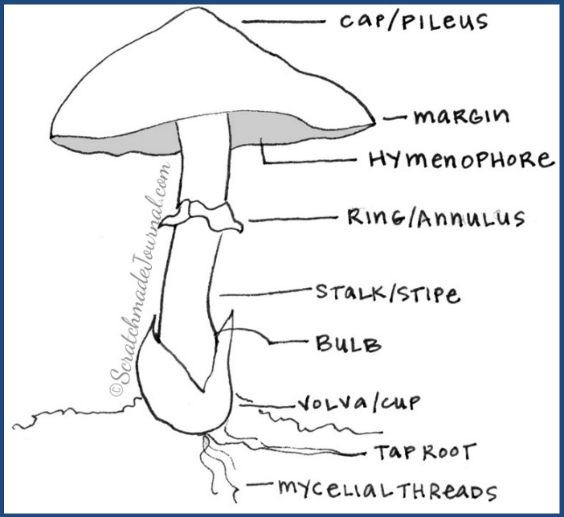
- Illustrate how a jellyfish gains nutrients using the following concepts: nerve net, nematocyst, gastodermis, epidermis, mesoglea, ect….



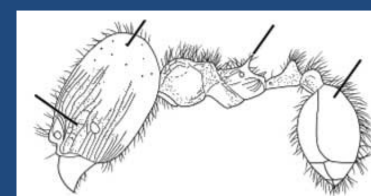


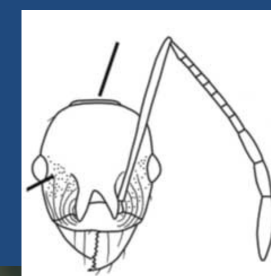
Why I draw?
Why should everyone draw?

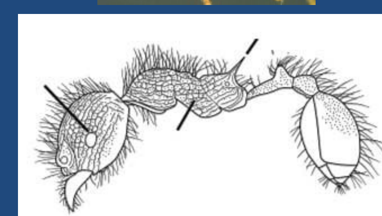




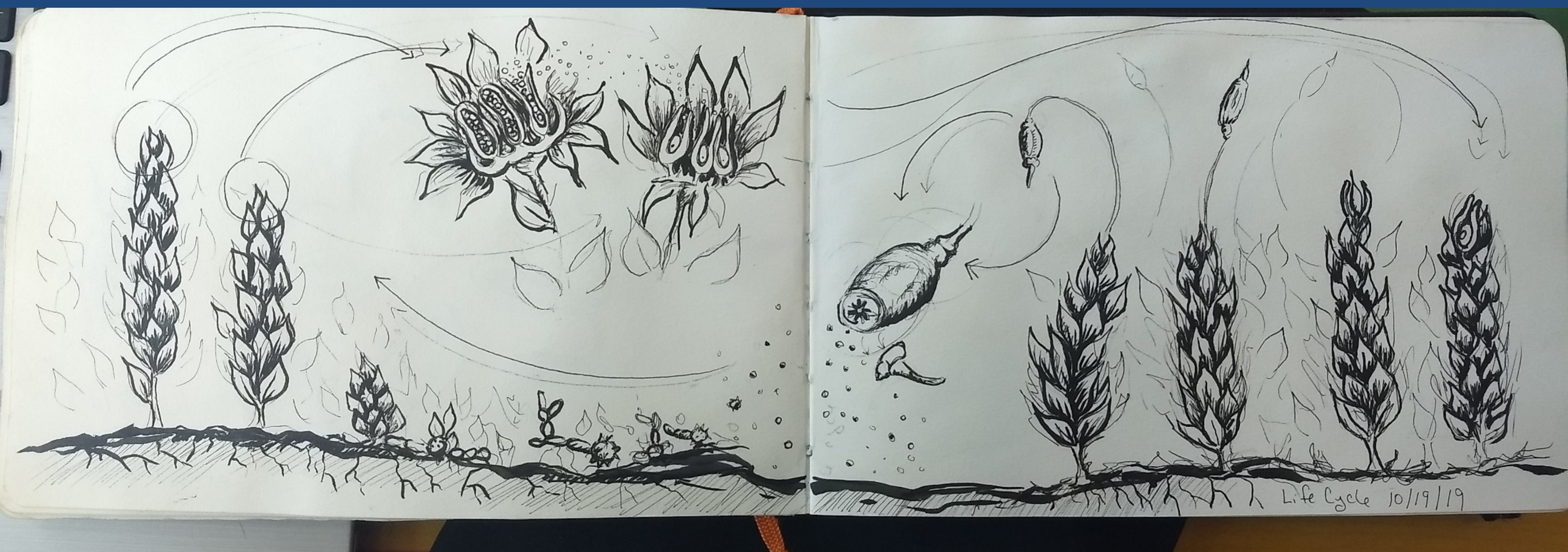
Drawing to educate myself

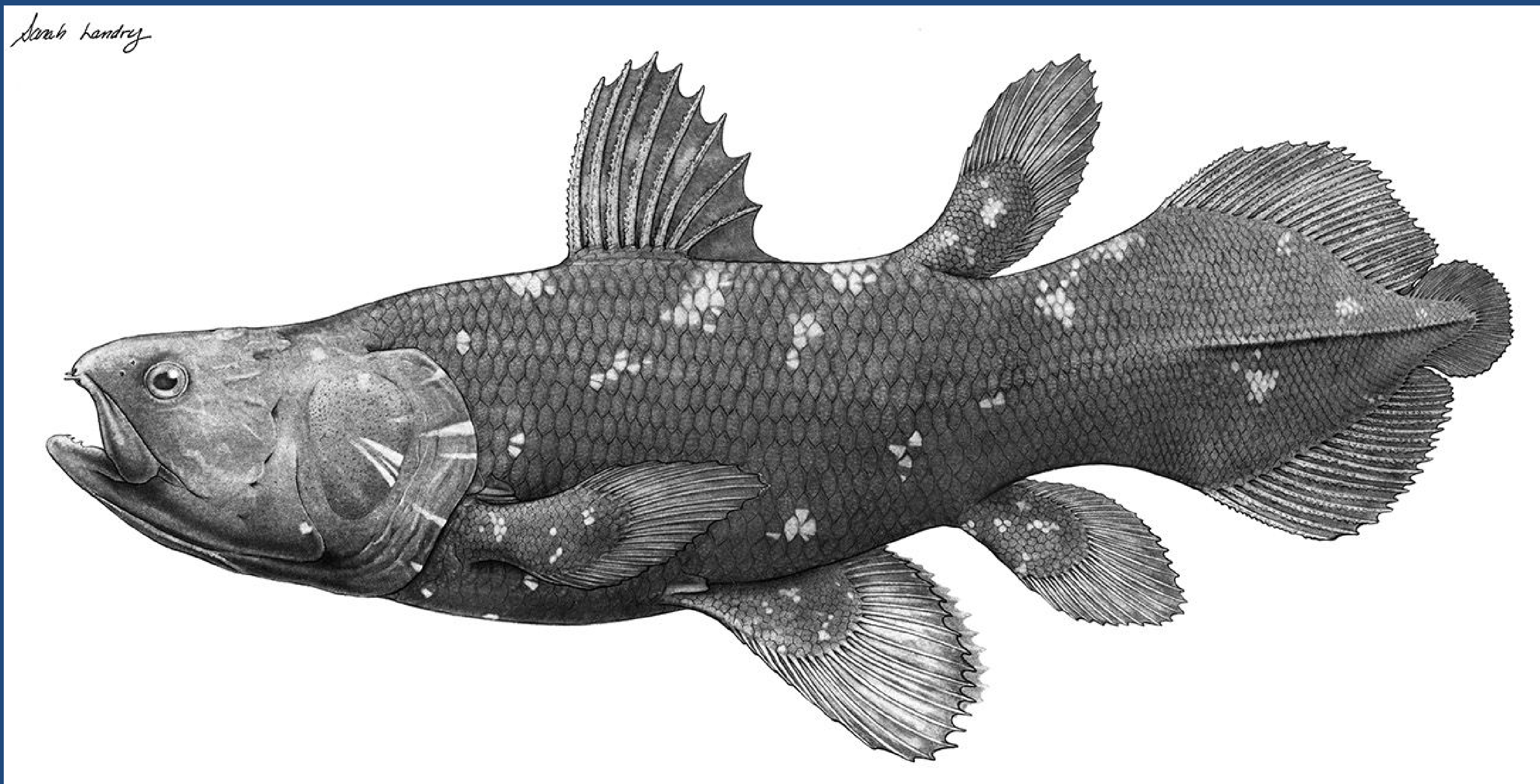




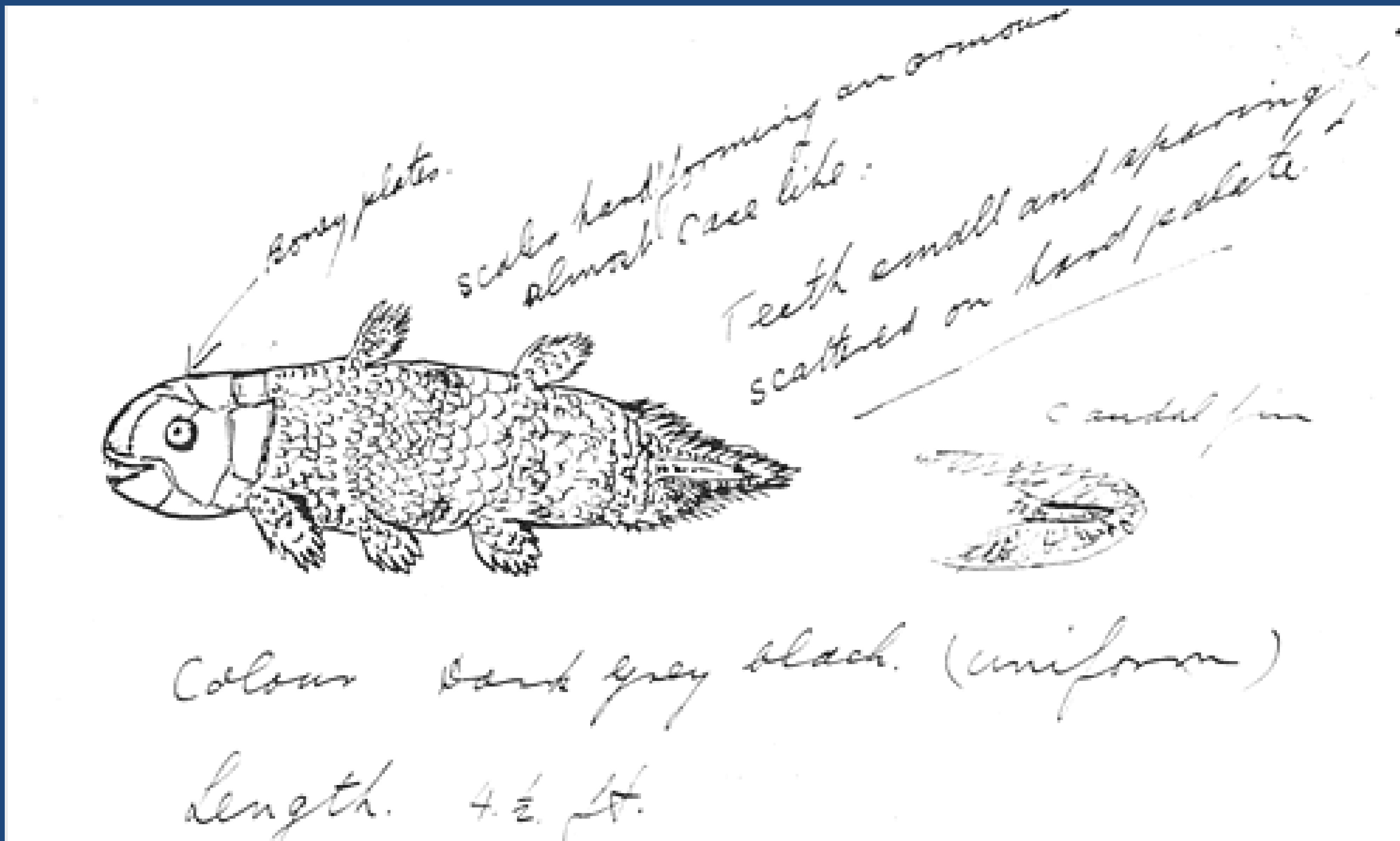


Always learning new things:




Sarah Landry

Marjorie Courtenay-Latimer


Boney plates.
scales hard forming an armour
Teeth small and
scattered on hard palate
Caudal fin
Colour Dark grey black. (uniform)
Length. 4 1/2 ft.

“Scientific Illustration is a marriage of science and art in a way that’s elegant and informative. I want the information to be beautiful, but if it doesn’t deliver the information, it’s ultimately a failure.”

- Edward Bell
Retired Art Director
Scientific American magazine

If you have a creative side nurture it!