Attic learners are scientists! They learn the scientific process through inquiry, experimentation, authentic documentation, and a sense of discovery. Our science education is developmentally appropriate and makes use of kids' individual curiosities, the rich natural setting of our campus, and hands-on activities to encourage deep understanding of scientific principles. At our high school level, learners are offered a strong schedule of traditional academic sciences, all still taught with constructivist pedagogy.

Science Workshop- Quail
The Young Child as Scientist, by Christine Chaille and Lory Britain.

Science is taught using a constructivist and inquiry-based workshop approach.

It is an opportunity for children to develop logical-mathematical thinking, while learning science by doing science.

This child-centered approach allows students to be scientists at their own developmental level, working on their own with a variety of science sets, and conducting their own investigations.

Mini-lessons and interactions with teachers reinforce the types of questions scientists ask and the skills scientists use, such as predicting, observing, and recording. At this level, our teaching focus is on the scientific *process*, as opposed to specific content.

Students choose from sets, such as water drops, magnets, bulbs and batteries, motors, gears, structures, marble runs, balance, cars and ramps, tops and spinners, light and mirrors, float and sink, chemistry, seeds, Private Eye magnifiers, and nature.

Children discuss reasons scientists record their work. As part of their own work as scientists, children record observations and discoveries (using sketches, words, symbols, numbers, and steps) and have an opportunity to share with each other their ideas, questions, and individual investigations.

At our annual spring Science Event, children share with our community what they've worked on in science.

A few of our favorite science books for kids:
Raindrops Roll, by April Pulley Sayre
A Drop of Water, by Walter Wick
What is a Scientist? by Barbara Lehn
After A While Crocodile: Alex's Diary, by Dr. Brady Barr and Jennifer Keats Curtis
Bridges are to Cross, by Philomen Sturges and Giles Laroche
Ada Twist Scientist, by Andrea Beaty
One Bean, by Anne Rockwell
A Pillbug's Life, by John Himmelman
A Slug's Life, by John Himmelman
An Earthworm's Life, by John Himmelman
Wiggling Worms at Work, by Wendy Pfeffer
Are You a Snail? by Judy Allen
Simple Science Experiments with Marbles, by Eiji Orii
Snowflake Bentley, by Jacqueline Briggs Marzollo
Electric Gadgets and Gizmos: Battery-powered buildable gadgets that go! by Alan Bartholomew
A Handful of Dirt, by Raymond Bial
Mirette on the High Wire, by Emily Arnold McMillan

Check out (do this literally, from the library!) the Harper Collins **Let's Read and Find Out Science** series and the list of award winning **Outstanding Science Trade Books for Students K-12,** put out each year by the National Science Teachers Association (NSTA).
http://static.nsta.org/pdfs/2019OSTB.pdf

Science Inquiry & Investigation – Snow Goose

Science inquiry and investigation is taught in a workshop format in which student scientists "do what scientists do"—ask their own questions and design their own investigations.

Typically, the class explores two or three topics at a time with every individual or small group pursuing their own inquiry question or individual project.

Scientists spend time developing questions, testing and retesting ideas, making discoveries, and sharing their findings with their peers.

Teachers respond to what they see and hear in student investigations by engaging in a dialogue and presenting science content designed to nudge student-scientists to their learning edge.

Scientists have opportunities to practice concepts related to the scientific method, such as developing testable questions, stating hypotheses, designing methods to test these hypotheses, and drawing conclusions from tests that are conducted.

Results of science inquiry are recorded in a science notebook with an emphasis on documenting, as clearly as possible, one's procedures and findings.

Areas of physical, chemical, and natural science are explored. Some favorite topics at this level have been the physics of marbles and ramps, engineering and reverse engineering, mini go-carts, magnetism and electricity, insects and spiders, botany, soap bubbles, recipes and cooking science, salmon/creek exploration, properties of ice, and bridges and structures.

At our annual spring Science Event, children share with our community what they've worked on in science.

Books to support and inspire our work as scientists:
Notable Notebooks: Scientists and Their Writings, by Jessica Fries-Gaither
Women in science: 50 Fearless Pioneers Who Changed the World, by Rachel Ignotofsky
Ada Lovelace, Poet of Science, by Diane Stanley
Ada's Ideas, by Fiona Robinson
Animals by Numbers: a Book of Animal Infographics, by Steve Jenkins
Spit and sticks: A Chimney Full of Swifts, by Marilyn Grohoske Evans and Nicole Gsell
A Beetle is Shy, by Dianna Hutts Aston
Chasing at the Surface: A Novel, by Sharon Mentyka
Inside of a Dog: What dogs see, smell, and know (Young Readers Edition), by Alexandra Horowitz
Poop Detectives: Working Dogs in the Field, by Ginger Wadsworth
Smithsonian Rock & Gem Book, by DK press
The Fantastic Ferris Wheel: The Story of Inventor George Ferris, by Betsy Harvey Kraft
Welcome to New Zealand: A Nature Journal, by Sandra Morris
The Hidden Life of Trees: The Illustrated Edition, by Peter Wohlleben
The unbelievable Bubble Book, by John Cassidy
Bubbles (Boston Children's Museum Activity Book), by Bernie Zubrowski
Shadow Play: Making Pictures with Light and Lenses (Boston Children's Museum Activity Book), by Bernie Zubrowski
Mirrors: Finding Out About Light (Boston Children's Museum Activity Book), by Bernie Zubrowski
Raceways: Having Fun with Balls and Tracks (Boston Children's Museum Activity Book), by Bernie Zubrowski
Tops: Building and Experimenting with Spinning Toys (Boston Children's Museum Activity Book), by Bernie Zubrowski

Check out (do this literally, from the library!) the list of award winning **Outstanding Science Trade Books for Students K-12**, put out each year by the National Science Teachers Association (NSTA). http://static.nsta.org/pdfs/2019OSTB.pdf

Excerpts from the **Scientist in the Field** books also make good read-alouds for this age-group**.**
http://www.sciencemeetsadventure.com/books/

Teacher Resources:
Sciencing Toward Logical Thinking, by Daryl Phillips

Science Inquiry & Investigation – Merganser
Science investigation and inquiry are taught in a workshop format, focusing on the scientific process.

Guided by student-generated questions and teacher demonstrations to spark inquiry, we explore, analyze, and investigate the world around us. Typically, the class explores one or two topics at a time with every individual or small group pursuing their own inquiry question or individual project.

Students ask questions, develop procedures, take measurements, control variables, record and organize data, analyze results, and draw conclusions. Students keep a science notebook to record their procedures and findings. Students share their discoveries with their classmates on a regular basis and share a favorite investigation with our community at our annual spring Science Event.

Students at this level are able to start researching, actively assimilating, and presenting science content to their peers.

Favorite topics at this level have included properties of water, creek measurements, pendulums, density, chemistry and quantifying chemical reactions, electricity and electrical circuits, nature, native plants, salmon, insects, anatomy, structural engineering/structure building, wave behavior, and weather.

Students are exposed to the greater scientific community through experiences such as research, field trips, reading biographies (i.e. *Scientists in the Field*), sharing current events, and hosting guest speakers.

Books to support and inspire our work as scientists:
For this age group, be sure to check out the **Scientist in the Field books** http://www.sciencemeetsadventure.com/books/
The Orca Scientists, by Loree Griffin Burns
Backyard Bears, by Amy Cherrix
Amazon Adventure: How Tiny Fish are Saving the World's Largest Rainforest, by Sy Montgomery
Beetle Busters: A Rogue Insect and the People Who Track It, by Loree Griffin Burns
Digging for Dinosaurs: An Expedition to Madagascar, by Nic Bishop
Eruption! Volcanoes and the Science of Saving Lives, by Elizabeth Rusch
Crow Smarts: Inside the Brain of the World's Brightest Bird, by Pamela S. Turner
Hidden Worlds: Looking through a Scientist's Microscope, by Stephen Kramer

Other Titles:
The Story of Seeds: From Mendel's Garden to Your Plate, by Nancy Castaldo
Solving the Puzzle Under the Sea: Marie Tharp Maps the Ocean Floor, by Robert Burleigh and Raul Colon
Whoosh!: Lonnie Johnson's Super Soaking Stream of Inventions, by Chris Barton
Birdology: 30 Activities and Observations for Exploring the World of Birds, by Monica Russo and Kevin Byron
The Librarian Who Measured the Earth, by Kathryn Lasky
Stickeen: John Muir and the Brave Little Dog, by John Nail (retold by Donnell Rubay)
Tops: Building and Experimenting with Spinning Toys, by Bernie Zubrowski
Light Bulb: Turning Point Inventions Series, by Joseph Wallace
When the Earth Shakes: Earthquakes, Volcanoes, and Tsunamis (Smithsonian), by Simon Winchester
Making Waves: Finding Out About Rhythmic Motion (Boston Children's Museum Activity Book), by Bernie Zubrowski
Messing Around with Water Pumps and Siphons (Boston Children's Museum Activity Book), by Bernie Zubrowski

Teacher Resources:
Invitations to Science Inquiry, by Tik Liem
Simple Nature Experiments with Everyday Materials, by Anthony D. Fredericks
Astronomy For Every Kid: 101 Easy Experiments that Really Work, by Janice VanCleave
Creative Sciencing: Ideas and Activities for Teachers and Children, by Alfred DeVito and Gerald H. Krockover
Creative Sciencing: A Practical Approach, by Alfred DeVito and Gerald H. Krockover
Elementary Science Methods A Constructivist Approach, by David Jerner Martin
Nature Journaling, by Clare Walker Leslie
The Private Eye Looking/Thinking by Analogy, by Kerry Ruef
Classroom Creature Culture: Algae to Anoles: articles from NSTA journals, by Carolyn H. Hampton and others
Science Workshop: Reading, Writing, and Thinking Like a Scientist, 2nd Edition, by Wendy Saul and others

Science – Raven

At this level, students typically hunger for more content, and our classes focus on providing a basic understanding of a topic or discipline—be it physical, natural, or earth science. Content is approached in a constructivist manner with the emphasis on the learner actively constructing their understanding through readings, interacting with physical objects, and engaging in discussion. Students enjoy learning what it feels like to dive deeply into a topic and understand it. There is so much science content out in the world and our focus in the Raven science room is around learning to learn and students becoming experts on specific aspects of the curriculum that interest them. One is more likely to see a student than at teacher at the front of the room.

Learners are exploring a variety of key science skills, learning how to make sense of complicated text, digesting complex vocabulary, reading for understanding, looking up vocabulary they don't know, making connections to what they already know, making cross-disciplinary connections, and seeing through different lenses.

There is a consistent emphasis on generating and asking good questions. Scientists learn to observe, read, explore, and discuss, and then to ask 'what if…', 'what's next…', 'I wonder…'. The skill is to come up with good questions—to know what I don't know—to wonder, to ask, to propel oneself to the learning edge.

At Raven level students have an opportunity to select from a variety of science classes. Some past science course offerings at this level were:

Science Challenges

This course provided students the opportunity to explore various scientific topics through tackling challenges. Is it possible to build a bridge out of paper and glue that will hold a 75-pound student? Can you figure out which mixture of powders fits Mrs. Claus's cookie recipe? What is the best design to create a vessel out of a one square foot piece of aluminum foil that will hold the most weight? What is the best weight of paper for making a paper airplane? Through these long-term explorations, students in this class explored scientific skills and concepts such as force distribution, density, buoyancy, natural and chemical indicators, isolating variables, and engineering design process. Students in this class practiced as scientists: collaborating, asking questions, gathering evidence and data, conducting background research, running multiple trials, and writing lab reports.

Science: Archaeology

Students in this course acted as archaeologists, uncovering artifacts from our site that had been left there in the late 1950's. Students practiced gridding a site, carefully digging to uncover objects, and precisely recording where and what objects were found. As time went on and piles of objects were uncovered, it was necessary to switch to a less careful method so we could continue to harvest these artifacts. A research team stationed inside the classroom took in objects to clean and conducted Internet research. The class culminated in creating a small museum of the most interesting pieces found.

Science: Gardening

In this course, students designed and implemented their own experiments to test various conditions that affect the growth of garden plants. Experimental variables included soil composition, moisture, and depth; sun vs. shade; northern vs. southern exposure; and noise exposure. Throughout their various experiments, students learned about creating an experimental plan; isolating, controlling, and measuring variables; and drawing conclusions from results. The focus of this course then shifted from gardening to soil science. Students completed a site survey to test soil composition and acidity. They also learned about soil health by observing samples under a microscope and creating a compost pile.

Science: Inventions

Students in this course were inventors. They discussed and reflected on the various motivations for inventing, and learned about the invention process (identifying a need or problem, creating theoretical solutions, drafting a blueprint, creating a prototype, experimenting and tweaking). They spent the bulk of their time in class working directly with a wide array of materials to create and test inventions to address real world problems. As peers, students also provided feedback to fellow inventors and helped each other to hone their science and engineering skills.

Electronics & Engineering

Students explored electricity and its applications in electronics by creating simple circuits. Students practiced the scientific method by creating and recording experiments in their own experiment books. In class students developed their own intuitions about electricity by experimenting with a water circuit, breadboards, and various circuit components, and by drawing sketches and recording notes from experiments. Students learned how to use, interpret, and create basic circuit diagrams, and how to troubleshoot. Learning was demonstrated through correct completion of assignments, and by building working circuits. Homework included recording and evaluating testing results, completing electronics worksheets, and researching information related to the current topic. No books were required for this class, but worksheets and textbook excerpts were often given for homework.

Astronomy & Earth Science
This class introduced the basics of astronomy and earth science. To start, basic earth science topics were covered, from the interior of the earth to the features that cover its surface. Students gained an understanding of the processes that shape the earth around them, including plate tectonics, erosion, volcanoes, faults and the rocks themselves. We used these studies as a jumping off spot as we dove more deeply into the planets and features of our solar system, comparing the different planets and features found around our sun. Students then studied the evolution of the universe, starting with the Big Bang, expansion of the universe, formation development and properties of stars, and the possible endings of the universe. Learning was demonstrated though presentations and individual reports on topics such as earthquakes, volcanoes, planets, stars, galaxies, and nebulas. Students were expected to research their chosen topic and then present the information to the class on a weekly basis.

Introduction to Botany
This one-semester science class started with students browsing through a variety of botany resources, from college level texts, to field guides, to children's books on plants. Students mind-mapped topics they wanted to explore in more detail and helped determine the direction of the class. We started with broad biology concepts: natural observations, the five-kingdom system, basic life functions, cell structure, and a touch of biochemistry. The course then shifted to plants, starting with plant structure and function, divisions within the plant kingdom, seed germination, flowers and reproduction, photosynthesis, genetics and plant interactions with their environment. Students also designed and conducted experiments involving seed germination and growth; isolating variables, drawing conclusions and modifying their experiments in response to what they observed. Learning was assessed throughout the course using warm ups, writing assignments, notebooks, discussion, and in-class assignments.

Science - High School

High School science classes focus on continuing and deepening the approach to science content started in the Raven and Merganser (middle school) years. Learners dig deeply into topics using a constructivist approach. They continue to think and act like scientists, putting information into context and building their own understanding of the content by inquiring about and interacting with the information and materials in class. Attic high school science classes are engaging, thought-provoking communities where the learners are given space to explore the questions that interest them and to experience what it feels like to be a scientist. Classes are offered in the traditional disciplines of chemistry, physics, and biology, as well as in special topics based on student interest (such as robotics, evolution, and astronomy).

We see high school learners as self-directed, self-motivated, and intrinsically curious. Expectations for out-of-class work at the high school level include a great deal of independent learning (e.g. reading, outlining, questioning, and synthesizing). Our learners are expected to be responsible managers of their own work and leave The Attic confident to handle the rigor, depth, and breadth required of students at the college-level. Regardless of their post-Attic journey, however, Attic learners are empowered to take on the challenges of being informed and critical thinkers who ask questions, observe with detail, analyze with care, and synthesize information logically.

Some past science course offerings at High School level were:

Invertebrate Biology

Using the high-school/college level textbook *Animals Without Backbones*, by Ralph Buchsbaum, this class studied the world of invertebrates, focusing on the ways in which various invertebrates (earthworm, clam, squid, crayfish, and grasshopper) perform the varied life functions required for survival. Through dissection, reading, discussion, essay writing, and small group and independent projects, the class studied the anatomy and physiology of the life functions in depth. As well, students became familiar with the taxonomy of living creatures, learned Latin and Greek root words, and did live invertebrate investigations of crayfish and planaria. Learning was assessed throughout the course of the year through presentations, essays involving the comparison of different invertebrates, and comprehensive post-assessments for each invertebrate studied.

Introduction to Botany

In this rigorous course, learners studied plants and their interaction with the environment in detail through labs, readings, discussion, writing, small group, and independent projects. A variety of high-school/college level textbooks excerpts (including *Biology*, by Campbell, Reece and Mitchell; *Plant Biology*, by Rost, et al.; and *The Botany Coloring Book*, by Young), field guides, journal articles, Internet sites, and personal observations were used as resources. Students first gained a broader understanding of general biology concepts: the five-kingdom system, basic life functions, biologically important molecules, and cell structure. The course then focused on basic features of each of the major divisions within the kingdom Plantae, plant classification, anatomical features of plants, the plant life cycle, and genetics. Each student kept a detailed notebook, in which they recorded all notes, observations, experiments, and investigations. Learning was assessed throughout the course of the year through presentations, writing assignments and in-class projects.

Marine Biology

Using the high-school-level textbook *Marine Biology*, by Castro and Huber, this class focused on marine wildlife and marine habitats. The first part of the year centered on basic principles of marine science: the sea floor, chemical and physical features of the ocean, basic biology, and an overview of the major marine taxa. In the second half of this course, students studied representative organisms from the major phyla living in the marine environment. Through dissection, reading, discussion, writing, small group and independent projects,, the marine environment and organisms' life functions were studied in detail, allowing students to develop a better understanding of how marine organisms function and interact with the marine environment. Students also developed critical thinking skills, textbook reading strategies, note taking strategies, and research/writing skills.

Human Anatomy & Physiology

This high school-level course studied the structure and function of the human body using *Essentials of Human Anatomy and Physiology*, by Elaine N. Marieb. The class studied the anatomy and physiology of the different organ systems at a deep level through essays, drawings, class discussion, small group projects, presentations, in-depth homework assignments, 3-D modeling, and labs. As a yearlong project, students chose a specific anatomy topic they were interested in and completed a research paper and presentation. Labs included microscope observations of different cells and tissue types, blood typing, a pig heart/lung dissection, a cow eye dissection, and a fetal pig dissection. Learning was further demonstrated during a science event where different topics from the class were taught to younger students, including demonstrating a full dissection procedure.

Conceptual Physics

Physics was a fast paced, high school-level course with *Conceptual Physics,* by Paul G. Hewitt as the textbook. From Newton's Laws to wave interference, this course covered a wide range of physical science topics. Beginning with kinematics, the course began with a complex understanding of linear movement and vectors, projectile motion, and forces. Other topics that received in-depth coverage included sound and light, quantum mechanics, energy, momentum, and circular motion. We also covered properties of matter, thermodynamics, gravitational interactions, and electromagnetism. Exploration of each topic was heavily supported with hands-on, inquiry-based labs and projects. A high level of in-class participation was essential for success in this course, as much of the learning came from discovering complex processes through discussion and experimentation. Assignments included weekly reading assignments, practice problem sets, projects, presentations, and post-assessments.

Chemistry

This academically rigorous high school-level class explored the fundamentals of chemistry using Zumdahl's, *World of Chemistry*. Through lab investigations, discussion, problem-solving, and molecular modeling, students studied the following topics: matter, elements and the periodic table, atoms, ions, nomenclature, measurement and calculations, chemical composition, chemical reactions, modern atomic theory, chemical bonding, solutions, and acids and bases. The class also touched on radioactivity, states of matter, and organic chemistry. Lab investigations included observing physical and chemical changes, separation of a mixture, electric solutions, forming and naming ionic compounds, measurement and the SI system, chemical bonding, polar and nonpolar solvents, and pH indicators. Assignments included weekly reading assignments, practice problem sets, projects, and presentations.

Cell Biology

Cell Biology is an in-depth high school-level course using the texts *Biology*, by Campbell, et al. and *Essential Cell Biology*, by Alberts, et al. Through readings, discussion, molecular modeling, lab investigations, essay writing, internet research, and independent and group projects, we delved into the mechanisms whereby macromolecules of the cell cooperate to create a system that feeds, moves, responds to stimuli, grows, and divides. We studied the four main organic cellular molecular groups (carbohydrates, lipids, proteins and nucleic acids), cellular organelles, glycolysis, citric acid cycle and electron transport chain, protein structure and function, DNA replication, transcription and translation, chromosomes and gene regulation, membrane structure and transport, mitosis and meiosis, cell communication, genetics and biotechnology topics. Lab investigations included: survey of the Kingdoms at a cellular level, molecular modeling, diffusion and osmosis, enzyme investigations, DNA extraction, and cell division.

Evolution

Evolution was an in-depth, rigorous, upper high school-level course using the college-level texts *The Tangled Bank*, by Zimmer and *How Humans Evolved*, by Boyd and Silk. Through readings, discussion, presentations, internet research, and group and independent projects, students delved into the unifying principle of biology and a key concept for understanding the diversity of life on earth, evolution. Major topics covered included historical perspectives, evidence for evolution, the tree of life, molecular evidence, natural selection, genetics, the origin of species, biodiversity, sexual reproduction, evolutionary medicine and human evolution. Students were responsible for a large amount of reading, keeping a detailed notebook, leading class discussions, and assisted in charting the course of the class. Each student also read two scientific books of their choice and presented a report to the class discussing the major points from their books. The final class project was a detailed timeline mural that included three different scaled timelines and numerous events that had been encountered in the two textbooks and other reading materials.

Bio Expo

This optional, year-long, student-led research project involved choosing and working on a biology topic to enter into the Student Bio Expo. The Student Bio Expo was a unique science fair that engaged high school students to demonstrate their understanding of biotechnology and biomedicine in creative ways. Each student chose a biology topic and project category from a variety of forms—art, drama, music, molecular modeling, web design, traditional scientific research, multimedia, teaching, creative writing, or journalism. For all projects, students were required to do extensive research, write an in-depth scientific paper to rigorous standards, and present their findings to judges and spectators. The Bio Expo gave students an authentic and rigorous scientific audience for their work.