Research at the Mount Desert Island Biological Laboratory is based on the fundamental tenet that all life arose from a common ancestor. Humans are connected to even the most primitive organisms through this shared ancestry; all cells function in fundamentally similar ways, and all genomes have common attributes. MDIBL scientists study diverse animals such as sea urchins, roundworms, and marine and freshwater fishes - animals which on the surface seem to have little in common with each other, much less with humans. However, because they share many genes with us, they also share a remarkable amount of our biology.

Sea urchins, roundworms, and fish are less complex than humans and other mammals. This relative simplicity makes them powerful experimental models for understanding basic biological functions, human health and disease, and adaptations to environmental change. Research at MDIBL addresses fundamental questions, such as how do organisms develop? How do animals repair and regrow lost or damaged body parts? How and why do animals age? How do animals cope with naturally changing environmental factors as well as those introduced by humans?

As an institution, MDIBL focuses on understanding the connections that link all life and on using this understanding to improve human and environmental health. The Lab also promotes connections among scientists: leading researchers from all over the world come to MDIBL to work together, share their ideas and expertise, and train students. Thanks to the generous donors who recognize the importance of these connections, MDIBL continues to grow and deepen our understanding of life’s interconnectedness.

Kevin Strange, Ph.D.
Director, MDIBL
In his book *On the Origin of Species*, Charles Darwin proposed in 1859 that all life on earth arose from a common ancestor. Over the last two decades, the genomes of dozens of organisms, including humans, have been sequenced. Genome sequencing combined with powerful computational tools has provided overwhelming evidence for Darwin’s theory.

“Humans share a remarkable number of genes with even the simplest organisms,” says Kevin Strange, Ph.D., Director of MDIBL. “By studying animals far less complex than humans and other mammals, we can rapidly and economically gain new insights into how and why disease occurs.” For example, Dr. Strange studies the roundworm *C. elegans*. This tiny animal has 20,000 genes while humans have around 21,000. Humans and roundworms share about 75 percent of their genes. Because of this shared genetic information and the organism’s relative simplicity, *C. elegans* is a powerful model for understanding the biology that underlies all life.

Dr. Strange’s lab uses *C. elegans* to understand how cells cope with changes in their environment. These changes or “stressors” disrupt normal cellular function and can rapidly cause cell injury and death. His lab is particularly interested in understanding how cells sense stress and how they protect themselves from its damaging effects. Dr. Strange’s research focuses on osmotic stress, which occurs when cells lose or gain water. He has shown that loss of cell water or dehydration causes rapid and widespread damage to cellular proteins.

“It’s remarkable how quickly cells detect and repair or destroy damaged proteins so they can survive dehydration,” Dr. Strange says. “When we understand how they do this, we’ll understand human kidney function and disease much better. Understanding these repair mechanisms will also provide insight into human aging and disorders such as type 2 diabetes and Huntington’s, Alzheimer’s, and Parkinson’s diseases. This knowledge will make a difference.”
Randall Dahn, Ph.D., was the first scientist to document that skates and other primitive marine organisms grow complete new limbs as adults. The skate (a cousin of the stingray) has wing-like fins that are the evolutionary forerunner of our arms and legs. Dr. Dahn, who joined the MDIBL faculty in 2008, remembers his discovery “was a complete shock, in a way, because it had been published for a century that the only animals that could regenerate whole limbs were certain salamanders and newts. We simply weren’t expecting anything different.”

Yet Dr. Dahn (pictured opposite on right) experimented with skates after he read a non-scientific account by a home-aquarium keeper who had a stingray that lost one of its “wings” or limbs to a shark. To the author’s amazement, the stingray grew a new one in its place. Dr. Dahn has since found that at least one species in every major group of limbed vertebrates is able to regenerate its limbs.

“We’ve studied enough organisms to establish that limb regeneration was once the norm for all vertebrates,” he states. “We also know that these ‘primitive’ organisms share the vast majority of their genomes with more highly evolved organisms like mammals. Now we’re working on finding out exactly which genetic pathways control regeneration and whether we can use that knowledge to create new therapies.” A $1.6 million award from the U.S. Department of Defense is supporting the expansion of MDIBL’s Center for Regenerative Biology and Medicine and Dr. Dahn’s groundbreaking research.

“MDIBL is the best place for this kind of work,” says Dr. Dahn. “Here, I am surrounded by researchers who understand the importance of looking beyond conventional scientific models. Like the other scientists at MDIBL, I hope to harness the Great Experiment of evolution to advance human medicine.”
MDIBL scientist James Coffman, Ph.D., uses sea urchins as a model to study the basic processes behind every organism’s development and growth. His work has contributed to our understanding of human embryology, cancer, and environmental science, and his new studies of sea urchin larvae has implications for the growing field of aging research.

“Sea urchins are a premier experimental model,” according to Dr. Coffman. “They are a fundamental tool of developmental biology, and they continue to drive the field.” Sea urchin embryos are easily obtained - adults readily release millions of sibling eggs - and transparent, so that every stage of development can be fully observed.

A sea urchin embryo develops into a mature “pluteus” or larva in three to four days. The soft, free-swimming pluteus bears the beginnings of the sea urchin shell or “test” within it. After about forty days, it completes its transformation into a hard-shelled adult. When larva do not make this transition, they slowly deteriorate and die. Because the larvae are also transparent and they pass through their life span so quickly (unlike mature sea urchins, which can live for a century), Dr. Coffman is exploring their use as a model for studying how growth, development, and aging are related.

“Without basic science, we are largely clueless as to how the universe and life works.”

Dr. Coffman (pictured below on left) is motivated by the pursuit of new knowledge. “Without basic science,” he says, “we are largely clueless as to how the universe and life works. What we understand is miniscule next to what we don’t yet understand. Science is the best way to overcome our ignorance.”
Dioxins are among the most potent toxic chemicals known. Produced by industrial processes that use or burn products containing chlorine, including trash incinerators and paper mills, they are among the organic pollutants targeted by the United Nations for global elimination. Dioxins do not readily breakdown in the environment, and cumulative, long-term exposure is known to cause cancer and birth defects as well as damage to reproductive functions and the immune and endocrine systems. They permeate our food supply, and the World Health Organization reports that we all carry some in our bodies.

MDIBL scientists Antonio Planchart, Ph.D., and Carolyn Mattingly, Ph.D. (pictured right), are using zebrafish to discover the connection between dioxin and birth defects in the jaw and face. "Craniofacial" abnormalities, including cleft palate, are among the most common birth defects in humans. "It's been known for a long time that dioxin causes birth defects," says Dr. Planchart, "and that it disrupts craniofacial development. But what hasn't been known is exactly how it does that. We want to find out which underlying signals drive that area of development."

Zebrafish have a long history of being used in research on craniofacial development. Because their embryos are transparent, it is easy to monitor development. And because zebrafish mature quickly and their genome has been sequenced, it is easier to create new, genetically modified strains than it is with a model like a mouse. "Once we identify the genes that are affected by dioxin," Dr. Planchart says, "we can explore their role in craniofacial development by activating and de-activating them in zebrafish. When we understand their function, we can look for those pathways in human development, and see how they lead to deformities in children."

“What hasn't been known is exactly how dioxin causes birth defects.”
MDiBL’s leadership role in environmental toxicology goes back nearly fifty years and continues today. The first phase of research began in the 1960s and 70s as the public grew increasingly aware of environmental pollution from industrial and agricultural chemicals. Two of the Lab’s early year-round scientists, the late William Kinter, Ph.D., and his postdoctoral fellow, David Miller, Ph.D., had just shown that DDT caused eggshell thinning in raptors like the bald eagle when they turned their attention to reports of population declines among seabirds in 1976. “Our thought,” Dr. Miller recalls, “was that young birds would be particularly sensitive to environmental stress and that one source could be pollution, especially around oil rigs and spills.”

The results of their work with herring gull chicks changed thinking about how oil affected wildlife. As Dr. Miller says, “At the time we started, the feeling was that external oiling of feathers after a spill and resulting hypothermia was the big issue. Our work showed that even when birds were lightly oiled, they ingested toxic amounts of oil, and that young birds were most sensitive.”

MDiBL researchers continue to be interested in the effects of petroleum and in finding the best organisms in which to study those effects. David Julian, Ph.D. (pictured below in center), a Visiting Fellow from the University of Florida, is exploring how the presence of oil may change an organism’s ability to respond to other forms of environmental stress. He studies bloodworms in the sulfide-rich mudflats of Frenchman Bay in addition to the well-defined model organism C. elegans, a small roundworm, to learn which genes allow some species of animals to tolerate conditions that would be lethal to other species.

“Our work showed that even when birds were lightly oiled, they ingested toxic amounts of oil.”
MIDBL scientists address pressing environmental issues in a multitude of ways. From local projects such as studying the genetic effects of mine waste at the EPA Superfund site on Cape Roser, Maine, to establishing the massive Comparative Toxicogenomics Database to identify connections between chemicals, genes, and disease, our researchers continually apply their expertise to understanding the interplay between environment and health.

MDIBL’s strengths in toxicology, genetics, and bioinformatics are at the core of a new course in 2010, “Environmental Genomics.” The first of its kind in the world, the course is led by MIDBL Visiting Faculty members Joseph Shaw, Ph.D., and John Colbourne, Ph.D., both from Indiana University, and Ben King, M.S., MIDBL’s biostatistician. The course teaches researchers how to study changes in gene function on the level of entire populations when organisms are exposed to complex environmental conditions. Such experiments require that populations be split into smaller groups, exposed to one or more conditions, and then analyzed to determine the activity level of each gene in the genome. Large numbers of samples must be taken and huge amounts of data reviewed.

In the past, it’s always been expensive and time-consuming to do this kind of research,” says Ben King (pictured top right). “That’s why people use the reductionist approach and study one substance at a time. But that doesn’t mimic the real world, where multiple factors are always at work. We can use these new techniques to better model biological responses to environmental exposure.”
"Why am I coming to MDIBL? For an intellectual change of scenery," says Ken Poss, Ph.D., Associate Professor of Cell Biology at Duke University and a Howard Hughes Medical Institute Early Career Scientist. Dr. Poss (pictured right) is the first Maren Fellow in Regenerative Biology at MDIBL. "It will be great to visit a place where people regularly think about and study fish and other model organisms, comparative biology, and regeneration. I have a lab of 15 people studying tissue regeneration in the zebrafish model system, and there are some gaps in how we think about our research animals and our regeneration questions. I expect that the interactions and work we develop at MDIBL will help us fill those gaps."

Those interactions, combined with the Lab’s facilities and expertise with comparative model organisms, continue to draw fifty to sixty top-notch scientists to MDIBL every year as visiting faculty. Visiting scientists immerse themselves in the round-the-clock life of the Lab. They live in its simple cottages, mentor students, share ideas, and build collaborations with resident scientists and other visiting investigators. Like Dr. Poss, a new member of the visiting faculty in 2010, they look forward to refreshing their thinking and discovering new approaches and challenges in their research.

Christine Keating, Ph.D. (pictured below left) Associate Professor of Chemistry at Penn State, is another new visiting scientist in 2010. As a materials chemist and the first Bodil Schmidt-Nielsen Bioengineer-in-Residence, she represents a new emphasis at MDIBL on collaborations across disciplines. "I hope to learn about everything going on at the Lab," she says. "I plan to seek out opportunities for interaction with members of the MDIBL scientific community in areas such as nanostructure-enabled biosensors and artificial cells that can act as models for living biological cells."
Billy Hudson, Ph.D., the 2003 recipient of the Homer Smith Award for his outstanding contributions to kidney research and the Elliott V. Newman Professor of Medicine at the Vanderbilt University School of Medicine, will be coming to MDIBL in 2010 as the first Epstein Fellow in Molecular Physiology. “We would like to go back to the sea to explore the mysteries of the kidney ultrafiltration mechanism, as did Homer Smith [a long-time MDIBL investigator], but using modern molecular approaches to study marine animals.”

Yet the connections between Dr. Billy Hudson (pictured bottom far right) and MDIBL extend beyond shared research goals. In 2007, Dr. Hudson founded the “Aspirnauts” program in his native Arkansas. The program enriches science and math education in rural areas in innovative ways, such as turning long schoolbus rides into productive learning time with wireless internet connections and laptops.

“Science education is at a near crisis in the United States,” says Dr. Hudson. “Rural students are particularly underserved. I’ve walked a mile in these kids’ shoes, and I know the importance of mentors and exposure to science professions in setting high goals and finding a path to a meaningful career.

For the past two years, some of the Aspirnaut students (pictured right top) have participated in MDIBL’s summer fellowship program. MDIBL provides the kind of opportunities for mentorship and exposure to research that Dr. Hudson knows is so vital to raising aspirations and creating new scientists. “The Aspirnauts who were at MDIBL last summer have introduced marine biology to the other students,” Dr. Hudson reports. “Now we have a seventh grader - in Arkansas - who says he wants to be a marine biologist.”

MDIBL is also expanding its programs for underserved rural high school students from Maine. The Academy of Genomics will bring twelve rising high school juniors from across the state to MDIBL for a week in August to learn laboratory techniques for genetic sequencing and how to incorporate bioinformatics into genomic research. The program is supported by the National Center for Research Resources through the Maine INBRE program, which links MDIBL, as lead institution, with The Jackson Laboratory and eleven Maine colleges and universities to increase capacity to conduct biomedical research statewide.
The Mount Desert Island Biological Laboratory
Statement of Financial Position
December 31, 2009
(with comparative financial information as of December 31, 2008)

**ASSETS**

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<tr>
<th>2009</th>
<th>2008</th>
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</thead>
<tbody>
<tr>
<td><strong>Cash &amp; Cash Equivalents</strong></td>
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<td><strong>Accounts Receivable (net of reserve)</strong></td>
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<td><strong>Total Assets</strong></td>
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**LIABILITIES & NET ASSETS**

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<tr>
<td><strong>Unrestricted</strong></td>
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<td><strong>Total Net Assets</strong></td>
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**Total Liabilities & Net Assets** | 23,739,959

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The Mount Desert Island Biological Laboratory
Statement of Activities
Year ended December 31, 2009
(with summarized financial information for the year ended December 31, 2008)

**OPERATING ACTIVITIES**

<table>
<thead>
<tr>
<th>2009</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Federal Grants &amp; Contracts</strong></td>
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<td><strong>State Grants</strong></td>
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<td><strong>Other Government Grants &amp; Contracts</strong></td>
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<td><strong>Operating Support &amp; Revenue</strong></td>
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<tr>
<td><strong>Operating Expenses</strong></td>
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<td><strong>Change in Net Assets from Operating Activities</strong></td>
<td>(538,028)</td>
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**NON-OPERATING ACTIVITIES**

<table>
<thead>
<tr>
<th>2009</th>
<th>2008</th>
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</thead>
<tbody>
<tr>
<td><strong>Change in Net Assets from Non-Operating Activities</strong></td>
<td>352,631</td>
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</tbody>
</table>

**Total Change in Net Assets** | (185,397)

**Net Assets, Beginning of Year** | 8,063,405  |
**Net Assets, End of Year** | 7,878,008  |

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The financial statements of the Mount Desert Island Biological Laboratory for the fiscal year ending December 31, 2009, were audited by Horton, McFarland, and Veysey, LLC, and are available upon request.
The Mount Desert Island Biological Laboratory is extremely grateful to the donors listed on the following pages who have contributed generously to support the Laboratory’s scientific mission and education programs. We have made every effort to ensure the accuracy of this list. Our sincere apologies if any omissions or errors have occurred.

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