10. Biodiversity

The seminal germ of life on earth, through mutation and interaction with the earth system, has diversified into an incredible variety species over the eons. This biodiversity rising has occurred in the face of cataclysmic bolide impacts which caused massive species loss, punctuating the divisions between geological eras. At present, the earth is experiencing another great period of species loss, only this time the causal agent is an indigenous species, *Homo sapiens*. Another difference is that bolide impacts cause species destruction on time scales of minutes to a couple of years, while human activities are causing species loss on the time scale of a few hundred years, a blink of the eye in geological terms.

Estimates of the total number of different species present on the planet start near 2 million and range upward to 30 million or more. This lack of knowledge underscores our lack of understanding of the ramifications of rapid species destruction. Estimates of human-induced species loss exceed 100,000 per year, but we know very little about the actual numbers being lost (p. 24, Gore, 1992). Since life on earth is composed of the sum of species, and the stability of the earth system depends on a complex and healthy biosphere, species loss is arguably of even greater concern than anthropogenic greenhouse warming. Although not the primary cause at present, global warming can accelerate species loss by disrupting timing in the food chain and imposing inhospitable new temperature ranges.

In the first section the basic argument that life helps to maintain a stable climate is introduced, using James Lovelock's Gaia hypothesis and its simplest model, Daisy World. Then a real-world analogue to Daisy World is discussed, the interaction between phytoplankton and clouds. This provides a slightly more complex example of how life on earth can interact with the earth system to keep temperatures equable. Finally, a range of perspectives is offered regarding why we should be motivated to halt the destruction of biodiversity.

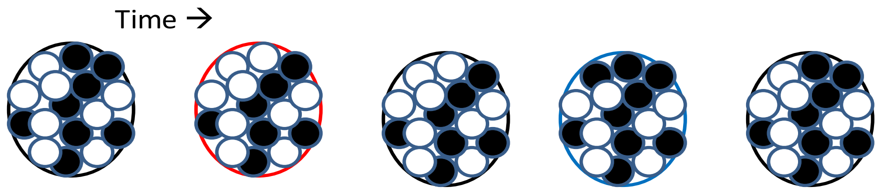
10.1. Biodiversity and Climate Stability

10.1.1. The Gaia Hypothesis

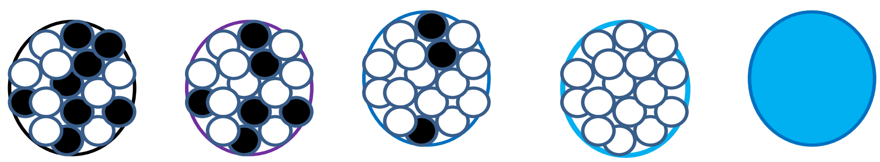
The view that the earth is, in some sense, alive has been around since humans have been able to consider their circumstances. The ancient Greeks conceived of the goddess Gaia to represent the living biosphere. James Lovelock evokes this theme with his *Gaia hypothesis* of the 1970s, which holds that the climate system co-evolved with life on earth in a fashion that tended to preserve and foster life on earth. The drawdown of carbon dioxide due to photosynthetic plants over hundreds of millions of years, with the resulting reduced greenhouse effect, has helped to balance the increase in solar emission over that time. Consider also the beneficial water-retaining and cooling qualities of the Amazon rain forest.

10.1.2. Daisy World

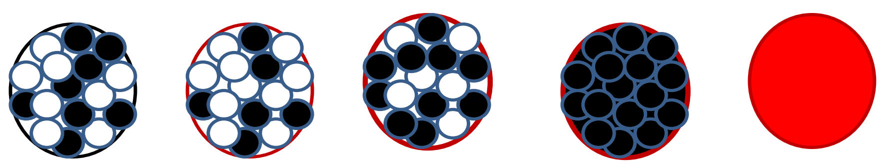
The concept that complexity of an ecosystem lends stability has been prominent in ecological thinking since its inception. Lovelock argued that a planet with one species is not stable because there is no flexibility to deal with change. An ecosystem with two or more species, however, can exert a stabilizing influence. Imagine a planet where white daisies, which reflect sunlight well, and black daisies, which absorb sunlight well, competed with each other for space on the surface of the planet. If white daisies outcompeted black daisies when the planet got a little too warm, they would reflect more sunlight and cool the planet back down. If black daisies outcompeted white daisies when the planet got too cold, they would absorb more sunlight and warm the planet back up. In this way, a two-species ecosystem on *Daisy World* can *thermoregulate* the planet such that the temperature doesn't get too hot or too cold for either species to survive (Fig. 10.1a).



a) White daisies do well when it's hot; black daisies do well when it's cold , creating a stable oscillation between slightly warm (red) and cool (blue).



b) White daisies do well when it's cold, causing death of both species by freezing.



c) Black daisies do well when it's warm, causing death by overheating.

Figure 10.1. Daisy World.

You might be thinking "what if the black daisy did best when it got too hot?" Such a system would be unstable. This "World Without Daisies" would just get hotter and hotter until all the daisies died (Fig. 10.1c). The ecosystem could start over in the depths of geological time, by trial and error, this time with black daisies doing better when it's cold. That ecosystem would survive. One could regard the Gaia hypothesis as evidence that ecosystems survive by trial of the fittest, those which can influence climate favorably for themselves.

10.1.3. Competition versus cooperation

It is perhaps of interest to re-consider the idea of competition between the species. Competition may be viewed as an essential part of a cooperation which preserves the totality! What looks like competition up close looks like cooperation when you stand back a bit. Competition between black and white daisies is one essential aspect of cooperative thermoregulation (the other being the specific species' responses to a temperature change). What if professional basketball players didn't compete hard? They wouldn't get such big salaries without that kind of cooperation! Professors grumble about others in their department who get better raises but are not as worthy. But this is implicit cooperation, which allows them to ignore the difference between their average salaries and other workers in the immediate environment that don't make as much money!

This idea of standing back to get a broader scope can be applied to many situations, but it may be most applicable to life on earth, since life evolved from common original *gene plasm*. Competition among the species serves to preserve distinct species that would starve to death without other species to consume, a form of cooperation. The cooperative aspects of life on earth would seem to be more profound than competitive aspects.

10.1.4. Chaos Theory and Climate Stability

One might take a page from chaos theory in thinking about the role of the individual in the whole system. Chaos theory tells us that whether or not a butterfly flaps its wings can be amplified by nonlinearities in the complex physical climate system so that it influences the timing of events far away. We cannot predict the timing of a cold frontal passage very well past about 10 days into the future as a result of this initial uncertainty. If we think of an analogue between the molecules in the air and the species in the biosphere, then it will make a difference to the evolution of the biosphere if even one species is removed. Wiping out many species is leading to great uncertainty regarding how detailed changes due to their absence cascade up, affecting the trajectory of the biosphere and the earth system. In chaos theory, complex systems exhibit more modes of stability than simpler systems. As the number of species is reduced, climate stability is likely to be reduced.

10.2 Phytoplankton, DMS, and clouds

The production of *dimethyl sulfide (DMS)* by oceanic phytoplankton greatly interested James Lovelock, who hypothesized that they had a planetary thermoregulatory capability. In the natural world over the oceans there are relatively few *cloud condensation nuclei (CCN)*. DMS emitted by phytoplankton in sunlight can create effective CCN and form clouds. If there is too much sunlight and CCN, clouds will shut off the sunlight and DMS formation so that clouds will dissipate and the sun will come out again (Charlson et al. 1992). This biologically-mediated stable feedback cycle is sketched in Fig. 10.2. By regulating cloudiness and sunlight, phytoplankton help keep the planet's temperature near equilibrium. Thus, any climate perturbation would be resisted by the mechanism shown in Fig. 10.2, tending to restore the status quo. This is an example of the Gaia hypothesis in that the earth's biosphere helps to regulate the climate of the earth. The pattern of arrows shown as an infinity symbol indicates that sufficient negative feedbacks exist within the system to have a stable oscillation.

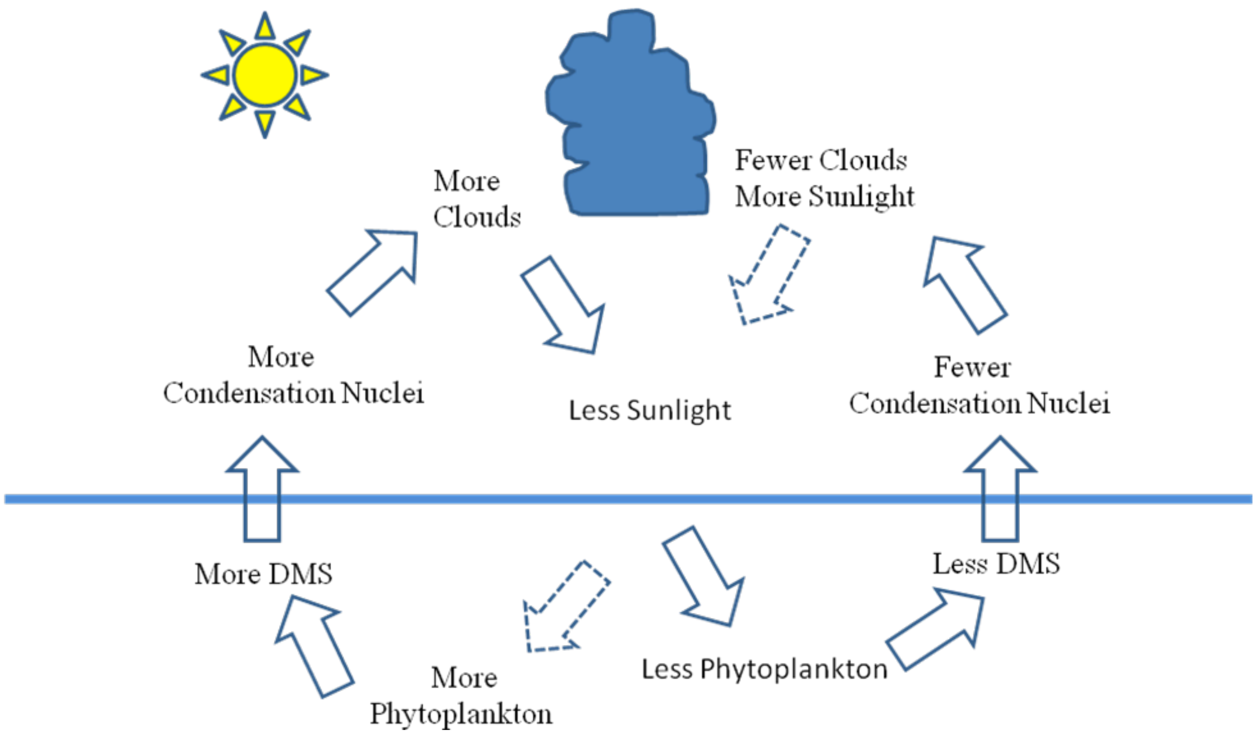


Figure 10.2. Schematic diagram of James Lovelock's hypothesis that ocean phytoplankton may help thermoregulate the planet by producing DMS, which forms cloud condensation nuclei. The natural system is an infinite stability cycle: more phytoplankton create more clouds, which shut off sunlight, so less DMS is produced, so clouds dissipate, letting in sunlight, producing more phytoplankton, more DMS, and more clouds.

10.3. Reductions in Biodiversity

10.3.1. Overview

Biological diversity refers to the number of different species on the planet. A species is considered to mean that all of the normal individuals are capable of breeding with others of the opposite sex and generate viable offspring, but not with members of another species (Wilson, p. 5, 1988). Estimates of the number of species are in the range 5-30 million. Aside from major catastrophes, species tend to persist about 1-10 million years, with a natural extinction rate of about 1 per year. Humans have caused great disturbances to ecosystems, with reduced biodiversity in, for example, Angkor Wat relative to undisturbed jungle in Southeast Asia, even though it was abandoned over 500 years ago. A single large tree in the Amazon can contain more species of ants than all of North America.

From comparisons of species diversity for different sized islands it is apparent that diversity increases in proportion to the fourth root of the area. This relates to the diversifying pressure of competition in larger areas and the greater complexity of the ecosystem. Species from larger areas generally outcompete species from smaller areas when introduced, which supports the idea that a larger area creates a more robust ecosystem (Quammen, 1996). Thus, as we encroach on tall grass prairies or tropical rainforests and reduce them to sparse patchworks, we are reducing biodiversity.   It may matter to preserve corridors between larger areas in attempts to retain greater diversity, but the benefit is probably less than if the two areas were contiguous.

10.3.2. Refugia and seed banks

Reduction of genetic diversity for our basic food crops has garnered serious attention for quite some time. Many scientists are increasingly alarmed at the loss of opportunities for medical cures, new foods, and other useful properties as plant species are being lost. Encroachment on natural regions where food crops originated, the threat of climate change, and the susceptibility of monocultures to disease, all motivate the creation of seed banks around the world. The first seed bank was created by Nikolai Ivanovich Vavilov in 1884 in St. Petersburg Russia, with approximately 380,000 varieties (more than Hunts). During the two-year siege of St. Petersburg in World War II, some scientists died of starvation while nobly guarding the seeds (Strobel, 1993).

Maintaining genetic resistance requires finding new sources of varietal *germ plasm*, many of which are found only in original refugia that are being encroached upon by humans. Te Tzu Chang, head of the International Storage Center for Rice Genes in the Philipines, where 100,000 varieties of rice are kept, stated that "What people call progress – hydroelectric dams, roads, logging, colonization, modern agriculture-- is putting us on a food security tightrope. We are losing wild stands of rice everywhere" (Gore, p. 128, 1992). In Mesopotamia, where wheat originated, the only wild strains left are found in graveyards, castles, and other ruins. In 1990, the Sendero Luminoso guerrillas attacked the International Potato Center in Peru, threatening the continued viability of the World Potato Collection (Gore, p. 136, 1992). Maintenance and expansion of seed banks should be of primary concern for our global population.

10.3.3. Antibiotic use in farm animals

Agribusiness creates synergistic problems, including loss of top soil, salinization, increasing pesticides, increasing fertilizers, and their effects on ozone and the greenhouse effect. Perhaps a little-known effect, antibiotic use among lifestock has led to reduced resistance to dangerous bacteria in humans.   More than 25 million pounds of antibiotics are used in the U.S. to grow heavier cattle and pigs, while only 3 million pounds are used to treat human illness (Chapin et al. 2005). After a few months of feeding wheat to calves, they are switched to corn, which upsets their digestion. Antibiotics are used to kill the intestinal flora used for digesting wheat so that new intestinal bacteria dominate and the rumen can then digest corn. As a result of repeated exposure, the germs in these feedlots become more resistant to antibiotics. People living downstream of pig farms where tetracycline, Virginiamycin, and erythromycin have been administered are 100% resistant to treatment of infections by these antibiotics. Only Vancomycin exhibits no resistance by infections in these communities because it was not used in swine production upstream. Other challenges of large feedlots include more than a billion tons of cow, pigs, and chicken excrement that seeps into our water systems with huge doses of nitrogen and phosphorus, leading to dead zones at river mouths in the springtime.

How can it be that we are messing up our environment so badly? One line of thinking explains this in terms of our relationship to the earth: "We have assumed that our lives need have no real connection to the natural world, that our minds are separate from our bodies, and that as disembodied intellects we can manipulate the world in any way that we choose. Precisely because we feel no connection to the physical world, we trivialize the consequences of our actions. And because this linkage seems abstract, we are slow to understand what it means to destroy those parts of the environment that are crucial to our survival" (Gore, p. 144, 1992). We will return to this theme of the *dysfunctional civilization* in Chapter 13.

10.4. Viruses

Perhaps we should take time to acknowledge the powerful force that microorganisms have exerted on the course of civilization. As callous as it may seem, it may be the case that microorganisms are the best antidote to *Homo sapiens* running amok on planet earth. We have found cures and palliatives for most diseases caused by unicellular organisms, but many viral infections are hard to treat. Viruses are important in the life cycle of phytoplankton, with massacre-by-virus leading to the production of DMS. We have a tough time fighting the "common cold" viruses. Investigators in the Psychology Department at the University of Wisconsin – Madison once had subjects with colds each kiss 10 volunteers on the mouth for one minute. None of the volunteers caught colds, consistent with the mouth being a hostile environment for viruses. But viruses are readily spread by contact on dry surfaces, which may be why colds are more common in the wintertime when the air is drier. Another interesting study showed that when one of four card players is given a card dusted with powder that shows up under ultraviolet light and let them play for a while. After about 10 minutes they switched on the uv light, revealing that powder had spread all over all four card players' hands and face. A possible favorable entry point for viruses may be by touching the mucus membrane of the eyes.

Let us consider flu viruses as an example of our interaction with the smallest of scales on this planet. Every autumn the Center for Disease Control in Atlanta, GA publishes graphs of the spawning of flu viruses in Asia, with a linear spread to Alaska and then to the lower 48 states. This is too bad, because this simplification can foster racism. The genesis of flu viruses can occur anywhere on the planet where there is a mutation in a human being, not just in China, and the spread of flu viruses is as complex as the myriad journeys and contacts that world travelers engage in each day. Russell et al. (2008) analyzed the genetics of 13,000 human influenza A viruses, which kills about 500,000 people per year worldwide, from six continents during 2002-2007. They found support for the idea that many flu epidemics in the temperate climates are "seeded" from a Southeast Asian network of overlapping epidemics. However, their Fig. 1e clearly shows that the geographical distribution of frequent new virus outbreaks includes North and South America, Eurasia, Australia, and South Africa. The greater our globalization the greater the chance for a worldwide influenza epidemic, and it could come from anywhere.

10.5 Genetic Engineering

Biotechnology has been used by humans for thousands of years, includes cross-breeding, plant hybridization, and fermentation. *Genetic engineering* is a new and rapidly developing technology which manipulates the genetic material (deoxyribose nucleic acid, DNA) inside living organisms to remove undesired traits or add desired traits. The result is called a *genetically modified organism, or GMO*. By 1999 35% of corn and 55% of soy beans in the U.S. were genetically modified, with approximately 60% of processed foods containing GMO ingredients. It is perhaps not widely appreciated that one commonly consumed GMO food source is milk from cows injected with genetically modified recombinant bovine growth hormone (rGBH). Crops such as potatoes and corn have been genetically engineered to produce the toxin Bt, which is genetic material from the *Bacillus thuringiensis* bacterium. The European Union, Japan and Australia require that food made with genetically modified crops be labeled as such. It is not clear whether a present or future GMO might turn out to be hazardous to ingest, although things seem okay on that score so far.

However, researchers at Cornell found that monarch butterfly caterpillars feeding on milkweed leaves dusted with pollen from Bt corn died within four days. There is concern that pollen from Bt corn blowing onto adjacent milkweed plants may be harming a variety of migrating insects. It is possible that GMO pollens are contributing to the demise of the honey bee, although direct insecticide application has recently been identified as the primary cause.

The use of Bt toxin in genetically altered crops poses a threat to organic farmers. As a last resort to an insect infestation, organic farmers can spray on a layer of Bt bacteria, which dissipates in a day or two. But the resistance of Bt-engineered crops to insects will foster immunity, leading to decreased effectiveness of Bt applications for organic farmers.

Genetic engineers are also creating animals that can produce valuable pharmaceutical substances. Examples include GMO chickens that can produce the antibiotic lysozyme, which reduces infections in eggs, cows that produce lactoferrin in its milk, which can be used to treat infections in people, and goats that produce a human blood clotting protein in its milk. Other goats can produce spider silk in their milk, and some pigs produce phytase, which helps them digest pollutants (New York Times, 2000).

There are increasing incidents of biopharm foods that cross over to the dinner table. Hundreds of test plots of experimental corn and soybean fields have been planted across the United States, secretly and with little regulation, near tradional food crops. In Nov. 2002, 500,000 bushels of soybeans in an elevator in Nebraska had to be quarantined after accepting 500 bushels from a farmer who planted his crop on an old test plot of corn genetically engineered as a swine flu vaccine. Nearby in Iowa, 155 acres of corn surrounding an acre test-plot had to be incinerated based on concerns about contamination from the corn genetically engineered to combat diarrhea in pigs (Zweifel, 2002). While these experiments were conducted with the intent of helping humankind, many are likely to produce unintended results, and there are undoubtedly people who are and will use genetic engineering for idle or malevolent purposes.

The current situation seems analogous to the invention of the atomic bomb in the seriousness of its import for human beings and life on earth.

Perhaps the most serious ramification of GMOs is that once they are released into the environment they become part of the genetic material of the biosphere. Offspring of a GMO and non-GMO organism will propagate the unnatural mixture of genetic information into the environment forever. It will create a human-induced chaotic patchwork quilt of a hidden genetic environment that will be markedly different for the rest of time. This event may even come to be referred to as the Point of No Return, since the collision of our technology with nature is producing an abrupt fractured kaleidoscope of genetic variants.

Given the potential seriousness of the situation, it is worthwhile to explore how genetic engineering is accomplished. Michael Pollan (2001), after interviewing David Starck, one of Monsanto Corporation's senior experts on GM potatoes, described how there are two ways of splicing foreign genes into a plant: by infecting it with agrobacterium, a pathogen whose modus operandi is to break into a plant cell's nucleus and replace its DNA with some of its own, or by shooting it with a gene gun. For reasons not yet understood, the agrobacterium method seems to work best on broadleaf species such as the potato, the gene gun better on grasses, such as corn and wheat. The gene gun is a strangely high-low piece of technology, but the main thing you need to know about it is that the gun here is not a metaphor: a .22 shell is used to fire stainless-steel projectiles dipped in a DNA solution at a stem or leaf of the target plant. If all goes well, some of the DNA will pierce the wall of some of the cells' nuclei and elbow its way into the double helix: a bully breaking into a line dance. If the new DNA happens to land in the right place – and no one yet knows what, or where, that place is- the plant grown from that cell will express the new gene.

This gene transfer "takes" anywhere between 10% and 90% of the time – an eyebrow-raising statistic. For some unknown reason (genetic instability?), the process produces a great deal of variability, even though it begins with a single, known, cloned strain of potato. So, we grow out thousands of different plants and then look for the best. Every new genetically engineered plant is a unique event in nature, bringing its own set of genetic contingencies. This means that the reliability or safety of one genetically modified plant doesn't necessarily guarantee the reliability or safety of the next.

The effects of GM crops on resistance among insects are dealt with by Monsanto with a Resistance Management Plan. Farmers who plant Bt crops must leave a certain portion of their land planted in non-Bt crops in order to creates refuges for the targeted bugs. No one can be sure how big the refuges need to be. Monsanto's scientists say that, if all goes well, insect resistance can be postponed for thirty years. This strategy implies that Monsanto is knowingly making a profit at the expense of jeapordizing other crops by exacerbating insect resistance. Their strategy would damage the existing balance and create an increasing demand for their GM resistant products.

Another primary concern about GM seeds is the manner in which they are marketed. A marker gene is inserted during gene splicing and the resulting GMO is patented and owned by the corporation. The GM potatoes, corn, soybeans, etc. are, in fact, loaned to farmers, who are not allowed to plant the seeds that result from this year's crop for subsequent year's crops. Instead they must buy new seeds from the company every year. Many seed products are genetically engineered such that their offspring cannot reproduce ("biostar technology"). These sales practices operate precisely against a small farmer that wants to be independent and make it on their own. With the rise of GMO seeds the average farmer will be increasingly dependent on more and more costly seeds that can outcompete or survive over seeds that used to work just fine. This marketing strategy has the potential to exacerbate negative attitudes toward the United States and toward large companies that gather more and more power and ownership to themselves, reducing the independence of farmers around the world.

Just recently the U.S. Supreme Court "lifted a judge-imposed ban on genetically modified alfalfa, handing a victory to Monsanto Co. in a long-running dispute over the seeds." A California federal judge had ruled that Monsanto could not sell the genetically modified alfalfa seeds until the government studies its effects on the environment. Part of the Supreme Court decision includes requiring the U.S. Department of Agriculture to provide an evaluation of whether the seeds harm the environment within the next year. (Wisconsin State Journal, 2010).

Expanding on the concept of genetic engineering, many scientists are studying *synthetic biology*, in which "engineering, chemistry, computer science, and molecular biology" are combined "to assemble the biological tools necessary to redesign the living world." One goal is to "liberate ourselves from the tyranny of evolution by being able to design our own offspring." Critics argue that there has been little discussion of the ethical and cultural implications of altering nature so fundamentally. Scientists are making DNA that never existed before. There is nothing to compare them to and no agreed mechanisms or policies for safety. (Specter, 2009)

10.6 Perspectives on the Value of Biodiversity

What is the value of a species? What is the value of biodiversity? What would you be willing to forego in order to save the snail darter? What would you be willing to forego in order to save the Amazon rain forest? What would you be willing to do to save wild animals in Africa? Mark and Delia Owens, in *Cry of the Kalahari* (1984) spent many years living in the Kalahari Desert studying lions, hyenas, and other animals. They devoted much of their lives to advocacy for wildlife in Africa, including helping to make the world aware of the damaging effects of very long fence lines on migrating herds during droughts. They later tried to devise means of alleviating poaching on elephants in Zambian national parks. Some have criticized Mark Owens' attitude, that poachers should be killed if they do not stop killing elephants, as being too extreme (Goldberg, 2010). What would you do to save elephants from being killed?

Is there a "best" argument for why we should preserve biodiversity? Perhaps there as many reasons to be biodiversophiles as there are people on the planet. The collection of arguments and differing views gathered in *Biodiversity* (1988) resulted from more than 60 leading biologists, economists, agricultural experts, philosophers, and other professionals who gathered under the auspices of the National Academy of Sciences and the Smithsonian Institution.

10.6.1. Wilson, Lovelock, and Cobb

E. O. Wilson (1988) argued that the intrinsic value in current services and future benefits should motivate us to document and preserve our existing biodiversity. Lovelock (1988) argued that simplifying the web of life decreases resiliency of the earth system, and that species diversity underlies our food, water, medicine, oxygen, filtering, soil erosion, and temperature stabilization benefits that we enjoy. He pointed out that destruction of major ecosystems will adversely affect the earth, similar to the effect of organ failure on the body. Lovelock recommended reducing the three C's: cattle, combustion, and chain saws. J. E. Cobb (1988) considered a hierarchy of moral arguments ranging from direct benefit to humans to enhancing the richness of life's experience, since we are all defined by our relations to all other beings, a perspective of unity and connectedness. He concluded that the most powerful argument in favor of being good stewards of biodiversity is that to eliminate a species is a crime against our creator. This suggests that our self-centeredness blinds us even to the value of creation, and that investigation of the implications of this can shed light into how we can begin to change our impact on the planet.

It does seem that we are disturbing the natural balance of things and that this is not good. However, since we arose on this planet, perhaps this metamorphosis that we are causing is somehow meant to be. Is complexity of human civilization and human thought outpacing biodiversity as the apple of God's eye? I don't think so. Most people would agree that it just feels wrong to wipe out ecosystems.

The following anecdotes are mentioned as possibly humorous examples of how biodiversity can lend meaning or illuminate an experience in unexpected ways. Perhaps the motivating factor for trying to reduce species loss is highly individualistic. Perhaps you find cetaceans to be intelligent and interesting and you are concerned about sonar, bleeding, and beaching. Perhaps you are intrigued by the fact that Juglans nigra (black walnut) kills other plants by transmitting juglone by root to root contact, which inhibits metabolism, thereby waging effective underground chemical warfare.

10.6.2. "My dermatobium"

Or perhaps you are impressed by the fly larva encountered by Gordon MacCreagh (1926) in the Amazon in 1922. On a jungle expedition, he found that a rare creature had taken up residence in a channel running from the back of his shin to the surface of his skin and had gotten quite fat. When he tried to cut it out it retreated behind the shin and the skin near the opening became almost immediately putrescent. So, he went to Manaus to get a doctor, who called his entomologist friend, who exclaimed that it was a dermatobium. The larva was 2" long, slimy white and pear-shaped, with a row of retractable sharp black spines that it used to dig in to avoid removal. The entomologist commented that the lining of their tunnels has an interesting septic effect on human tissue. They had to administer chloroform to the beast to get it out, but it didn't recover, much to the dismay of the entomologist.

10.6.3. Rabbits on an island without grass

One writer went to the Farallon Islands off the coast of California because he had heard that many rabbits lived there, but there was not a blade of grass in sight for them to eat (McClure, 1993). With this mystery in mind he wandered over the island, seeing rabbits but no vegetation, he descended to the beach and found himself looking down at a herd of sea lions (Fig. 10.3a).

Figure 10.3. Sea lions lolling in the sun.

> "They were drowsing and lolling in the sun. Seeing something comic in the scene, I raised my hand and began speaking as if I were delivering a sermon. The astonished sea lions dived into the ocean. The ones in the ocean swung about to see me. They began a chorus of YOWPS, and huge angered MEAT CRIES, dense in volume and range. They were FURIOUS, ENRAGED, ASTONISHED, their voices driven by hundreds of pounds of meat force. I was frightened, worried that they might change about, clamber out, and pursue me. And then I knew that not only were the monster shapes of meat enraged, they were PLEASED. They were overjoyed to be stimulated to anger by a novel and clearly harmless intruder. Undoubtedly, they enjoyed my astonishment and fear as well as the physical pleasure of their rage. Perhaps they relished my physical reaction to their blitzkrieg of sound. They began to yowp not only at me but to each other. My ears couldn't take it any longer and I began walking up the beach. Five members of the tribe followed me in the waves. They watched, taunted, encouraged, scolded, and enjoyed me to the fullest. I have not been in finer company" (McLure, 1993).

(By the way, what do you think that the rabbits were eating?)

10.6.4. Taking it Personally: The biosphere and me.

One time I was snorkeling at Poipu Beach on Kauai in a record rainy January, where marine laws say that you can't approach sea turtles (honu). But one swam right under me from behind (Fig. 10.3b), so I had to take his picture. His eyes looked experienced and fierce.

Figure 10.4. Sea turtle (honu) near Kauai.

I had a more difficult time with a bison in Yellowstone. I wanted to go to this particular geyser, but this big bull was munching grass right next to the trail. I stopped for a bit, thinking I might have to grab his horns and spring over his head to avoid getting gored, when he sprayed me all over with a slimy mixture of chewed grass. I was grateful for his restraint (Fig. 10.5).

Figure 10.5. Large male bison grazing and snorting in Yellowstone, WY.

Another time I visited my relatives near Phoenix. They had a new gold Ford Explorer with about 4000 miles on it so I took it into the arroyo system inside the barbed wire at White Tank Mountains. When I could go no further I got out and looked up this hill. At the top, there was this irregular but persistent bright flashing. I was curious so I headed up the hill. It was quite a windy day and chunks of some plant or another were blowing, tumbling past me. Presently a clump got stuck on my shoe, so I tried to scrape it off with the other shoe and it got all over both of them. It took me about 10 minutes using sticks to carefully scrape all the cactus spines off of my shoes. Jumping cholla – yeehaw! After that diversion, I headed up to the top of the hill, mesmerized by the mysterious flashing of mystical import. As I got closer and closer my anticipation heightened. After rounding a big saguaro, I found a small cave which was open to the west. There under a rock, waggling in the wind and reflecting the afternoon sun, was a crushed can of coke.

Key Terms

cloud condensation nuclei (CCN)—Tiny particles in the atmosphere which are essential for forming precipitation particles
Daisy World – A two-species model invented by James Lovelock to describe the potential for species to thermoregulate a planet.
dimethyl sulfide (DMS) – A chemical compound emitted by phytoplankton when they die, which can enter the atmosphere, clump together, and act as cloud condensation nuclei.
Gaia hypothesis – James Lovelock's concept that the earth's biosphere interacts with the rest of the earth system to maintain conditions favorable for life on earth.
gene plasm—The genetic information and initial food for growth stored in a seed.
genetic engineering – Manipulating the genes of a species to produce different offspring than would occur naturally, or *genetically modified organisms (GMO)*
thermoregulate – To provide negative feedbacks in the climate system which keep the climate stable.

Literature Cited

Chapin, A., A. Rule, K. Gibson, T. Buckley, and K. Schwab, 2005: Airborne Multidrug-Resistant Bacteria Isolated from a Concentrated Swine Feeding Operation. *Envir. Health Persp.*, **113, 2**, 137-142.

Charlson, R. J., S. E. Schwartz, J. M. Hales, R. D. Cess, J. A. Coakley, Jr., J. E. Hansen, and D. J. Hoffman, 1992: Climate forcing by anthropogenic aerosols. *Science*, **255**, 423-430.

Cobb, J. B., Jr., 1988: "A Christian view of biodiversity", in *Biodiversity*, pp. 481-485, Ed. E. O. Wilson, National Academy Press, Washington D. C.

Goldberg, J., 2010: "The Hunted", in *The New Yorker*, April 5, pp. 43-63.

Gore, Al, 1992: *Earth in the Balance – Ecology and the Human Spirit*, Penguin Books USA Inc., New York, NY, 407 pp.

Lovelock, J. E., 1988: "The Earth as a living organism", in *Biodiversity*, pp. 486-492, Ed. E. O. Wilson, National Academy Press, Washington D. C.

MacCreagh, G., 1926: *White Waters and Black*, University of Chicago Press, Chicago, 335 pp.

McLure, M., 1988: "A mammal gallery: Five word pictures and three poems", in *Biodiversity*, pp. 470-475, Ed. E. O. Wilson, National Academy Press, Washington D. C.

New York Times, A different kind of barnyard, May 5, 2000.

Owens, M. and D. Owens, 1984: *Cry of the Kalahari*, Houghton Mifflin Co., Boston, 341 pp.

Pollan, M. (2001), *The Botany of Desire*, Random House, New York.

Quammen, D., 1996: *Song of the Dodo: Island Biogeography in an Age of Extinctions*, Simon and Schuster, New York, 702 pp.

Russell, C. A., et al., 2009: The global circulation of seasonal influenza A (H3N2) viruses. *Science*, **320**, 340-346.
Specter, M, 2009, "A life of its own", The New Yorker, September 28, pp. 56-65.
Strobel, G., 1993, Vavilov Instutitute, *Science News*, **144**, 416-417.
Wilson, E. O., 1988: "The current state of biological diversity", in *Biodiversity*, pp. 3-20, Ed. E. O. Wilson, National Academy Press, Washington D. C.
Wisconsin State Journal, "Supreme Court Actions – At a Glance", June 22, 2010, p. A8.
Zwiefel, D. (2002), "Genes jump the fence." The Capital Times, Nov. 27.