The Feminine Face of Science

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My focus has been a bit different than bringing more women into science. I am encouraging the inclusion of qualities that have been called feminine, such as feeling, nurturing, and receptivity, which are inherent in both men and women. I was curious what we miss seeing of reality and of the natural world when we don't include these qualities. I wrote my book *Lifting the Veil: The Feminine Face of Science* to explore how their inclusion might make science more complete.

When the institutions of science were forming in England in the mid-1600s their stated objective was to create a "Masculine Philosophy." The word "feminine" was used to disparage Aristotelian science and French science. Calling something "masculine" was to praise it, calling it "feminine" was an insult.

Robert Boyle wrote that there can be no greater male triumph than "to know the ways of captivating Nature, and making her subserve our purposes."

Masculine science was characterized by thinking, reason and abstraction. It was about the head, the intellect. It was active, virile and competitive. Its goals were about control and exploitation of the natural world. These could be achieved through objective experiments, reducing and analyzing the hierarchy of nature to smaller and smaller bits.

Medical texts in the late 1900s applied the law of conservation of energy to assert that the body can't expend energy on two tasks simultaneously and do both well. They advised adolescent girls to reduce their brain work, arguing that mental labor

caused infertility in women.

These characteristics defined what it meant to be a scientist over the centuries. In 1938 the journal *Science Education* called for scientists to:

- Deliberately renounce all emotion and desire
- Think coldly
- Be impersonal and disinterested in thinking
- Be dispassionate, and thoroughly self-controlled in thinking

As a result, qualities that were considered feminine were excluded from science. Feeling and a heart connection to nature were judged irrelevant. Receptivity was thought to be passive and weak. Subjectivity was believed to be dangerous. Multiplicity and diversity were too messy. Nurturing was a waste of time. Cooperation required giving up the illusion of independence. Intuition was unreliable and fanciful. Relatedness made controlled experiments too complicated.

Up until my lifetime, it was difficult for women to succeed in science without a man to open the door for her. Even Marie Curie would not have been recognized with the Nobel Prize if her husband Pierre had not insisted she be credited for her work along with him.

So what do we miss seeing of Nature when we don't include the feminine perspective? I want to emphasize that the characteristics that Western culture has defined as masculine and feminine are all human qualities, which we can all develop. By expanding our perspective as individuals, we can expand the perspective of science. This yin/yang symbol is a good image for showing that we need both to be truly whole.

Feeling tells us what is valuable and ethical — and what is repugnant. In research, the feminine can inform the whole process of science and technology, from what questions we ask, to how we relate to the research subjects, and how we apply the products of science in the world beyond the laboratory.

Love for animals, plants or an awe for the Creation often draws people to do science.

Jane Goodall loved animals and devoted decades to gaining the trust of wild chimpanzees and getting to know them intimately. She redefined what it meant to be human by showing that animals also used tools. Now her love for chimpanzees motivates her to go beyond studying them, to helping to protect them and their habitat.

Receptivity is about listening to Nature. But it's not a passive process. It takes patience, alert awareness, openness, reflection, and responsiveness.

One example of what we miss seeing of nature is the role of the egg in the process of fertilization. Biology texts describing fertilization emphasized the passivity of the egg waiting for the sperm to awaken it, the way the prince's kiss awakened Sleeping Beauty. But Gerald and Heide Schatten discovered that the sperm doesn't burrow into the slumbering egg. Instead, the egg surface extends small fingerlike projections called microvilli, which clasp the sperm and draw it into the cell.

Although this mound of microvilli had been observed since 1895, it had been ignored because of the belief that the egg was passive. The Schattens demonstrated that the egg and sperm are equally active and receptive partners carrying on a biochemical conversation of enzymes and secretions.

Multiplicity is about webs of interaction rather than hierarchical structures. Webs are inclusive and diverse. Bacteria, beetles and earthworms each play a significant role in the soil food web. No one member is more important than another. Physicists aren't more important than biologists. Scientists and lay-people can all perform vital roles in science.

Multiplicity is broadening, giving us different ways of seeing. We must learn to embrace duality. Light can be seen as *both* particles *and* waves.

The science of complexity allows us to see nature as generative and resourceful, abundant and interconnected.

Unlike tidy hierarchical structures, webs of interaction are chaotic. Chaos theory represents the feminine and demonstrates that precise prediction and control is

impossible in complex systems. Yet there is always order within chaos.

Rather than imposing hierarchical structure on matter, or reducing the universe to a single equation you can wear on your T-shirt, chaos scientists explore how systems organize themselves spontaneously. Instead of looking to a "leader" to create order, these systems use feedback loops to enhance movement toward a new level of organization.

Nurturing takes a long-term approach and is present at every level, like every aspect of the feminine. Nurturing students in science. The environment the Principal Investigator establishes in the laboratory. Institutions that nurture scientists. Research that values nurturing as important. Doing science that nurtures the planet and helps us live in harmony with Nature.

Just as nurturing has been devalued by society, it has also been dismissed in science—even at the cellular level—as uninteresting. For example, the function of glial cells in the brain has largely been ignored, since these "helper" cells were thought just to feed nerve cells and clean up afterwards—playing the "little lady role." Although glial cells are ten times more numerous in the brain than neurons, they have been neglected in favor of studying more active, exciting nerve cells.

This disdain of neuroscientists to study cells that play a mere nutritious role forestalled findings that glial cells participate in communication between the brain and the rest of the body. By moving back and forth between the brain and the body (where they become a type of white blood cell of the immune system), glial cells destroy the myth of the blood-brain barrier—a physiological reflection of the Western belief in the separation of mind and body. Interestingly, the number of glial cells per neuron increases as mammals ascend the phylogenetic scale from mice to humans. And the only difference found between Einstein's brain and 11 other male brains is that his had the most number of glial cells per neuron.

Cooperation is about working in harmony with colleagues, with researchers in other fields, and with nature. Symbiosis is the science of cooperation. But because there

has been a tendency to see nature as competitive, the role of cooperation remained obscure. Researchers who mentioned symbiosis were rarely granted funding.

The work of Lynn Margulis illustrates how the Feminine shifts our perspective and gives rise to radically new questions about nature. She demonstrated that symbiotic relations abound, and many affect entire ecosystems.

She presented evidence that biological diversity arose as much by microbial cooperation as through Darwinian competition. Now almost all biologists agree that mitochondria (energy producing organelles) and chloroplasts (photosynthesizing organelles) were originally free-living bacteria. She maintains that a major source of evolutionary novelty is the acquisition of symbionts, not just the accumulation of mutations.

Knowledge or insight gained without evident rational thought is unpredictable and mysterious—and so intuition was called feminine in Western culture. But we miss seeing important aspects of reality by denying intuition—a frontier of science that includes the study of consciousness and psychic phenomena.

Throughout the history of science, there have been tantalizing stories of scientists receiving insights from such nonrational sources as dreams. The most cited example is 19th century chemist Kekulé, who dreamed of a snake biting its tail. He awoke "as if by the flash of lightning" understanding the ring structure of benzene, a problem that long had eluded chemists. Physicist Niels Bohr dreamed of a planetary system as a model for atoms, which led to a Nobel Prize. Mendeleev conceived of the periodic table in a dream.

Because intuition is unpredictable and individual, coming as a whole in a flash, it cannot be broken down to study its component parts. The study of psychic phenomena calls for a different approach to research and new methods to handle subjective information and unique experiences.

Feeling, nurturing, receptivity, multiplicity, cooperation, intuition—all are based on

interdependence, a keen awareness of relationship to the other and to the whole. In contrast, science has pursued the masculine path of logic and analysis based on separating and compartmentalizing. This path has great power and has produced the marvels of modern technology, but it's also led to environmental problems.

Scientific knowledge is power. It also brings with it responsibility. In some cases, science has given humans the powers of the gods.

So how do we want to use the tremendous power of science? One choice has been the unleashing of nuclear energy, which has given us the problems of nuclear war and the unsolved problems of nuclear waste. Genetic engineering has been used to create new forms of life by combining genes of radically different species.

The qualities of the feminine can lead us down a different path, toward living in harmony with nature, rather than extracting from, manipulating and controlling nature.

One wonderful example is the field of biomimicry and the work of Janine Benyus. Biomimicry is the science and art of emulating Nature's best biological ideas to solve human problems.

Science has learned a lot **about** the natural world, but Benyus stresses the importance of learning ***from*** the natural world. She advises us to emulate the genius of nature.

When asked why she does what she does, she says "I do it out of amazing love for this sweet world. Pure love. It is an incredibly competent universe that we live in. You can live abundantly in a way in which you sip energy, you use a minimal amount of materials to meet your needs, and you live as a community that actually is able to enhance the place that you live. Life creates conditions conducive to life."

Another aspect of the feminine is subjectivity.

Your perspective, and the questions you ask, frame what you see. For example, how would Nature:

- Capture & conserve energy? We have a tremendous amount to learn from plants.
- How would Nature solve green building challenges?
- Gather water?
- Conserve materials?

Scientists are learning from termites mounds how to design buildings using natural ventilation. The Eastgate Building in Zimbabwe is passively cooled and maintains a relatively constant temperature. Plus it saved the builders $3.5 million up-front.

Nature banks on diversity. Benyus and her colleagues maintain a wonderful database at AskNature.com, which lists over 1200 nature-inspired design strategies we can learn from, including 35 different strategies for gathering water in Nature.

Benyus created online community spaces at AskNature.org and WiserEarth.org to connect people, nonprofits and businesses working toward a just and sustainable world.

Researchers are learning from the thorny devil, with grooves on its spikes that provide drinking water condensed from dew.

Bumps on the back of this desert beetle collect and condense fog into water. When the beetle lifts its hind legs, the water rolls into its mouth. Humans have mimicked this to create panels that harvest water.

The Four Steps to Biomimicry start with receptivity, which means quieting human cleverness so you're in a state to learn. Second is listening to Nature through deep observation, looking to the natural world for advice about how to live here more sustainably. Third is studying and emulating Nature.

For example, Benyus took a group of people to Costa Rica, and for the first day they took pictures of scenery. By the second day, they'd learned to look at organisms and ask them what they're doing. Then the participants began to take close-ups of a

beetle's exoskeleton. One person was working on packaging, and for her it was a revelation because the exoskeleton is packaging that breathes, signals, creates its beautiful color without toxic chemicals, is waterproof, abrasion-resistant is manufactured in a completely nontoxic way, and is completely recyclable.

The fourth step is saying thank you, and protecting the wellspring of good ideas that've evolved over eons. The best way to say thank you is to protect the habitat that the organism evolved in. Benyus founded the Biomimicry Guild and the Biomimicry Institute and they ask companies to donate a percentage of their proceeds to protect the habitat of the organism that inspired their products. It's a way of saying thank you. It's good manners.

Biomimicry is an exciting example of the marriage between masculine and feminine science: In addition to rigorous scientific experimentation and analysis, biomimicry research is:

- Inspired by love of Nature and the desire to protect it, and
- Receptive to what we can learn from the multiplicity and diversity of Nature's strategies.
- Biomimics subjectively ask: how would Nature solve our problems more sustainably?
- These scientists cooperate with colleagues and other organisms,
- Nurture Nature by saying thank you, and
- Intuitively understand how all aspects of Nature are related.

Imagine what your field of science would look like when the feminine is incorporated. What different questions will be asked? What methods might change? How will its results be applied differently?