Ancient animals got a rise out of oxygen

If today's insects scare you, consider the Goliath flies that ruled the skies during Earth's Carboniferous period 300 million years ago. Some souped up dragonflies had wingspans rivaling those of crows. Mayflies grew to sparrow size. On the ground, silverfish, scorpions, and other arthropods reached epic dimensions.

Blame it on the air, says a controversial new theory. A team of physiologists and biomechanics experts hypothesizes that elevated concentrations of oxygen in the Carboniferous atmosphere helped some invertebrates evolve bodies much larger than those seen today.

"Oxygen was an enabling factor, just like fertilizer in your garden," explains Jeffrey B. Graham, a marine biologist at the Scripps Institution of Oceanography in La Jolla, Calif. Graham developed the theory along with Nancy M. Aguilar of Scripps, Robert Dudley of the University of Texas at Austin, and Carl Gans of the University of Michigan in Ann Arbor.

Geochemists have long maintained that the proportion of oxygen in the atmosphere has varied on a geologic timescale, but few biologists have considered how such changes would have affected life. In the May 11 NATURE, Graham and his coworkers propose that enhanced oxygen concentrations profoundly altered evolution.

"I've been waiting for some paleontologists to worry about oxygen. Somebody finally has," says geochemist Robert A. Berner of Yale University. Six years ago, Berner suggested the idea of a Carboniferous atmosphere with oxygen concentrations of as much as 35 percent, compared to today's 21 percent.

Oxygen accumulated in the atmosphere then, according to Berner, because much of the dead vegetation sank into the abundant swamps instead of decomposing—a process that pulls oxygen from the air. At the start of the Permian period, about 286 million years ago, oxygen values started falling, eventually dipping to 15 percent.

Berner's model remains uncertain because scientists lack direct evidence about ancient air. But Graham and his coworkers note that if oxygen amounts did indeed increase during the Carboniferous, it may explain why giant dragonflies appeared at that time. Unlike vertebrates, whose circulatory system delivers oxygen to inner cells, insects absorb atmospheric gases through a network of branching tubes that carries air into the body. Interior cells receive oxygen through diffusion, a system that limits the size of invertebrates, the researchers maintain. With more oxygen in the air, invertebrates could have developed bigger bodies.

The additional oxygen would also have helped early flying insects, the scientists suggest. Although the first flyers lacked aerodynamic wings, they would have received extra lift from the denser atmosphere.

Our own ancestors may have benefited as well. During the Carboniferous, four-limbed amphibians clambered out of the swamps and started colonizing the continents. The extra oxygen in the atmosphere may have boosted the efficiency of their primitive lungs, suggest Graham and his colleagues.

With little evidence to support such contentions, the new theory will draw fire from many researchers.

"The fossil record of terrestrial vertebrates does not show convincing correlation with the postulated increase and subsequent decrease in atmospheric oxygen," comments vertebrate paleontologist Robert L. Carroll of McGill University in Montreal.

But Conrad C. Labandeira, who studies insect evolution at the Smithsonian Institution in Washington, D.C., calls the new idea intriguing and worthy of testing through laboratory experiments. Graham and his colleagues hope to examine how insects function in chambers with extra oxygen. *—R. Monastersky*

No harm in adding a little testosterone

Adding testosterone to estrogen replacement therapy (ERT) can help women combat postmenopausal mood symptoms such as depression and loss of libido. Now, new research indicates that the male hormone, contrary to some fears, doesn't reduce the established cardiovascular benefits of ERT.

Researchers from the Bowman Gray School of Medicine at Wake Forest University in Winston-Salem, N.C., found that postmenopausal macaques treated with estrogen plus testosterone experienced the same degree of protection from heart disease as animals receiving estrogen alone.

Veterinarian Janice D. Wagner reported the results in San Francisco this week at an American College of Obstetricians and Gynecologists meeting. She says the work may significantly "increase the quality of life" of millions of women.

ERT is commonly prescribed to relieve symptoms associated with menopause, such as hot flashes and vaginal dryness. It also helps to prevent osteoporosis and cardiovascular disease.

Despite the benefits, only 10 percent of postmenopausal women use ERT. Wagner says the number one complaint of women getting replacement estrogen is that they "don't feel well." When testosterone is added, Wagner says, women have far fewer complaints.

But estrogen-testosterone formulations are approved only for mood symptoms and hot flashes because of fears that testosterone might undo estrogen's cardiovascular benefits.

The Bowman Gray team tested an estrogen-testosterone formulation in macaques made postmenopausal by removal of their ovaries. The animals provide a good model to test cardiovascular effects of menopause because "they rapidly develop cardiovascular disease after surgery while on a high-fat diet," says veterinarian Michael R. Adams, the group leader.

In his team's study, 12 macaques received estrogen, 12 got estrogen plus testosterone, and 12 served as controls. Monkeys in both treatment groups had one-third to one-sixth the LDL, or "bad" cholesterol, of the control group.

And, when the researchers measured enzymes associated with bone loss, the treated groups had 40 percent less bone loss than controls.

"The addition of testosterone doesn't negate the positive cardiovascular effects of estrogen," Wagner says. And, because women tolerate estrogen-testosterone better, it is likely that more would use replacement therapy. Wagner hopes human trials will follow. *— L. Seachrist*

Nitrogen: Breaking it up is hard to do

Though humans live in a sea of nitrogen, which makes up 78 percent of Earth's atmosphere, chemists have had a hard time harnessing the inert gas for practical purposes.

Nature takes exquisite advantage of gaseous N_2, "fixing" nitrogen by means of biological processes that split the tightly bound molecules before weaving individual nitrogen atoms into compounds. Yet the seemingly simple task of nitrogen fixation continues to stymie chemists seeking easier ways to use the gas in industrial processes.

In the May 12 SCIENCE, chemists Catalina E. Laplaza and Christopher C. Cummins of the Massachusetts Institute of Technology report a novel process for splitting up N_2. They use an intermediate molybdenum-containing molecule to cleave the two nitrogen atoms.

Since nitrogen plays such a strong role in organic chemistry, a technique that makes the element more available for chemical synthesis offers great practical opportunities, the chemists observe. Such a method "is clearly desirable if this immense natural resource is to be utilized optimally," they say.

Not surprisingly, the feature that makes nitrogen so stable and inert — a