Modern Meteorology in Metaphors

If this essay ever be completed or published, it will be because it brings together three persistent themes in my life that I have hitherto been unable to integrate.

First, I have been an evolutionist for sixty years. Only about half way along, however, did somebody\* point out to me that the major concepts of evolutionary theory -- natural selection, adaptation, phyoogeny, evolution itself, and even the very notion of species -- were *metaphors*. Having gained that insight, metaphors suddenly appeared everywhere in science, atoms, plate tectonics, black holes, the “mind inside” were all obvious metaphors. Most scientists that I knew at that time treated metaphors with contempt, the sloppy tools of poets and novelists that should be let nowhere near the laboratory bench. But being thoroughly familiar with the history of evolutionary theory, it was immediately apparent to me that the metaphors of evolutionary theory had been, and continued to be, rich heuristic tools for description, analysis and explanation of the form and behavior of organisms. If you take metaphors seriously, you can work them. Generally, metaphors that one stumbles upon, as if, having a nail and needing a way to pound it in, a rusty hammer were suddenly to be found lying about in the duff. However, But scientist have also become adept at designing for-purpose metaphors, “models”. Models are devices designed to represent the workings of some otherwise-mysterious natural process. Models can be mechanical, mathematical, or agent-based. Like all metaphors, models are to some degree facetious, but are nonetheless useful for generating and validating hypotheses concerning the workings of nature.

Second, before and throughout my career in behavioral evolution, I have been an amateur meteorologist. Meterology is a discipline replete with metaphors. Weather events are conceptived as the result of agents we call storms. Storms have appendages we call fronts. Fronts pen off contesting regions of cold and warm air. When a storm directs one region against the other, violence ensues. One might even think of meteorology as a behavioral science, if one thinks of a behavioral science as one that explains events in terms of the actions of developing entities.

Finally, my father was a publisher of trade books and taught me that nothing is truly understood until it can be taught to a curioius, attentive, well educative lay persion. My own 40 years of teaching college psyhology enforced that lesson. In this regard, mteorology bears another similarity to behavioral sciences. Like them, it is a subject that curious, attentive well-educated lay persons already know a lot about. Not only do they live within it, they have, through television, magazines, books of the month club, etc., been acquainted with many scientific concepts. We lay persons know a thing or two about the behavior of people and storms, and we are unlikely to relinguish lightly any of what we have learned. For instance, if in a psychology class, I assert that your experience of making a decision always comes AFTER your decision has been taken, you will resist. And you are likely to fight back when I tell you, as I am doomed to in the next few pages, that air actually gets hotter as you climb a mountain and that the air at the top of Mt. Everest is, in some important sense, scalding hot.

This brings me to my third life long passion, the art of explaining complex, technical subjects in ways that navigate around the cruel obscurantisms of scientific jargon and beach the reader on a robust understanding of a subject through metaphor. Once one sees that metaphors lie at the living heart of a science, one can dream that by conveying the truthful core of these scientific metaphors, one can robustly convey to the reader the essentials of that science.

*Modern Meteorology in Metaphors* is my attempt to accomplish this feat. I say Modern, because today’s meteorology has begun to stray from its metaphorical roots. True, the main characters of 20th century meteorology -- storms, warm fronts, cold fronts, etc.—still play roles. But the metaphors of modern meteorology are much like those of gradient and flow and circulation and current. In 19th century we lived on a battle field of warm and cold armies contesting for territories. Nowadays, we seem more to rock in a giant, rotating, rocking bathtub with hot and cold water pouring in from taps at either end. Ach! It makes me seasick to even think of it.

Ok, then. To arrest the vertigo, let us launch ourselves into the Jetstream and see where it takes us.

**Introduction to your Jet Stream**

You have heard about “the jet streams”: mysterious “rivers” of air that writhe like pinioned snakes five miles up in the atmosphere. You have probably been nearer jet streams than you know. When, headed east of out of LA, your pilot tells you that he has reached cruising altitude at 39,000 feet, you are probably kiting along in a jet stream; if you are flying from New York, your pilot has probably found a way to avoid them. Depending on which way you are flying, a hard-blowing jet stream can add or subtract as much as a hundred and fifty miles per hour to your ground speed. Get into New York from Angeles Los an hour early? Favorable jet stream! Get into Los Angeles from New York an hour late on the same day? Unfavorable one! Pity the poor airline schedulers when their westbound flights arrive an hour early and their eastbound ones an hour late. Logistics Nightmare. It’s a wonder they do as well as they do.

But just how like a river is a jet stream? At the foot of the west field on my farm flows the Ware River, a proper “stream”. The Ware River is barely 30 feet across but when heavy rain drenches the valley above us, it can put on a pretty good show. Water careens around the upstream bend and tumbles down towards us in a noisy flood. Time was I could sit astride the end of a railroad tie, feet dangling over the water, and feel the trestle quiver as the water slid under me. Whirlpools would form up-stream and be carried down toward me, some growing large enough to bend the main flow, some shrinking to be gobbled up by others. Where boulders usually stood out in the river now were mounds of water trailing wakes of foam. Where the river became confined by abutments of the bridge, the water seemed to roll and curl under itself, leaving a central flow of fastmoving water surrounded by more placid back-eddies on either side. Rippling, bulging, sinking and swirling, the river’s surface was constantly changing.

How like my Ware River is a jet stream? Close, but not quite! The best metaphor for the jet stream is not the whole river, but that central flow where the constrained river forces itself under the bridge. Here, the bits of foam on its surface push and shove one another like revelers entering a trendy nightclub. Here the flow is fastest, and these fast flows are crammed near to slower ones or even to contrary ones. Like the fast flow under my bridge, jet streams are actually part of a much larger river, the Mid-Latitude Westerlies, the vast current of air that flows eastward between the tropics and the arctic regions. This Westerly “river” includes not only the fast-moving flows of the jet sreams but also the vast cyclonic and anticlyclonic gyres that form the low and high pressure centers that help to shape the jetstreams and are shaped by them. This way of thinking of Jet streams, not as streams themselves, but as regions of concentrated faster flow within a much larger river, is much truer to their nature. Jet streams are not continuous. They appear where the westerlies seem constrained as the air navigates around the northward advances and southward intrusions’ of the polar front.

Your weather broadcasters tell you that jet streams have a tremendous effect on our weather at the surface. This supposition has always puzzled me because, as you also know, the atmosphere is very thin at 39,000 feet, barely a fifth as dense as it is on the surface. You know that because your aircraft must be pressurized t to keep you alive.

 Why does such an ephemeral wind have such a momentous effect on the much more massive layers of air below it. Can a mouse move a brick? Well, it turns out that if the mouse is moving fast enough, it can. Imagine you standing on top of a 39,000 mountain, trying to maintain your balance in the wind. Let’s say you know that you can stand up to a 40 mph wind on the surface … not very well, but you can do it. How hard would that skinny jet stream wind have to blow to knock you over. You would think it would have to blow at least 5 times as fast, because the air is at least 5 times thinner. But that intuition is wrong. In fact, the wind would have to blow only twice the speed to have the same effect. Increases in the velocity of the wind have much more effect on its impact than its mass. Winds of one to two hundred miles an hour are common in the Jetstream. Even though a 125-mph jet stream wind is skinny, it has all the force of a storm-force wind on the surface and a 200-mph jet wind has all the power of a hurricane.

 Granted that these thin Jetstream winds are more powerful than their thinness might suggest, how do they exercise their power on the layers below. Friction would be the obvious answer, but that intuition is mostly wrong. The boundary between different layers of the atmosphere is “better lubricated” than you might suppose. A fast-moving layer overrunning a slower one will have surprisingly little effect on it, even if they are moving in the opposite direction.

The short answer to the power of the Jetstream is in its turbulence. Every time the jet stream twists or turns, rises or falls, rolls in one direction, or rolls in the other, it pulls up or pushes down on the atmosphere below it. Pushing down stabilizes the atmosphere; pulling up, destabilizes it. Whether the effects of jet stream turbulence are great or small depends on how stable is the atmosphere over which the Jetstream is flowing. You already know from our discussions of convection and the release of potential heat, the power of upward motions on the atmosphere. If, for instance, a column of air is raised to the altitude where its water vapor is condensed, then suddenly the column gets a jolt of released latent heat, as much as 20 degrees at lower altitudes where air carries the most moisture. We have already seen what happens when the summer sun starts that column moving upward, and that potential energy starts to get squeezed out: powerful thunderstorms. If a jet stream can also move the column upward, it can initiate the same process. And if both happen at the same time, the sky is the limit.