The Emerging Universe
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Our worship theme throughout the month of April has been emergence. Back when we were first discussing this theme in one of our Worship Associate meetings, I piped up and said I could give a wonky lecture on the scientific concept of emergence. Everyone seemed to like the idea, and in fact, they wanted me to title my sermon, “A wonky lecture on the scientific concept of emergence.” I didn’t go with that title, but that is essentially what this sermon is. So please forget for a moment that we’re supposed to be in church, and just pretend you’re watching Nova or Cosmos. That said, I am convinced that even the wonky scientific concept of emergence can have a deep spiritual significance. I’ll come back to that at the end of the sermon, or wonky lecture, or whatever else you want to call it. For now, let’s just dive in.

Have you ever watched a flock of starlings swoop around the sky like a kite, darting first this way, then that, the whole flock staying together as a single cohesive mass while it performs these aerial gymnastics? Have you ever wondered, “Who’s driving? Who’s in charge of that flock?” The answer, as far as we can tell, is that none of these birds is in charge. None of them, in fact, would even have the mental capacity needed to organize and direct an entire flock. No disrespect to starlings, but their tiny bird brains simply are not large enough for the individual birds to worry about anyone but themselves. Yet, if that’s the case, then who, or what, is keeping the larger flock organized as it careens around the sky like a single creature?

This is the sort of question a small group of scientists began asking in the 1980’s and 1990’s. They had noticed that many different natural phenomena seem to work this way, where a large group of individuals behaves in highly organized fashion, the group acting almost as if it were a single entity, yet no one seems to be directing this coordinated behavior—neither any of the group’s members nor some external leader. Another example would be an ant colony. True, the colony has a queen, but this queen does not sit on her throne giving orders to the rest of the group. Her sole job is to churn out baby ants. So she does her job, and the other ants do their jobs, soldier ants protecting the colony and worker ants gathering up food. And through this coordinated behavior, the colony as a whole is able to meet all of its collective needs, functioning like a well-designed machine. Yet, none of these ants has designed the machine, nor do any appear to have the job keeping the rest of the group organized. The organizing just seems to come about by itself, spontaneously. Yet, how is this even possible?

Somewhat surprisingly, this is not the sort of question that science, as usually practiced, is well equipped to answer. Ever since the Scientific Revolution of the seventeenth century, scientists have been pursuing a strategy known as reductionism. The French philosopher Descartes first laid out this strategy. If you encounter a complex problem, Descartes counseled, don't try to understand it all at once; you'll just get dizzy with all the details. Rather, break the problem down into its simpler parts, and if needed, break those parts down into yet simpler parts, until you have arrived at parts so simple they cannot be broken down any further. By this point, the parts should be so perfectly easy to understand that you will have achieved a complete, clear knowledge of them. At this point, you can just start putting the parts back together, and you will have achieved an equally perfect grasp of the original complex whole.

By and large, this scientific strategy of reductionism has been extraordinarily successful. In studying the fundamental nature of matter, for instance, scientists have taken the macroscopic objects we observe around us, like rocks and trees, and analyzed them down, not just into the molecules that compose these objects, but into the atoms composing the molecules, and into the subatomic particles composing the atoms. The knowledge thereby gained has allowed us to build everything from iPhones to nuclear bombs. Nevertheless, this reductionist approach is not terribly helpful for figuring out how an ant colony works, or how a flock of starlings stays together. The problem, in these cases, is that we are explicitly trying to understand how multiple individuals come together to function as a single unit. But when we proceed by breaking these larger wholes down to its simpler parts, we just end up with the parts, not the larger whole we are trying to study. To be sure, you can study a flock of starlings by examining each individual starling in isolation from the rest. And you can take one of these individuals and analyze down it still further, perhaps dissecting its brain. This will tell you many things about starlings, including the fact that an individual starling cannot possibly have enough brain power to organize an entire flock. But this analysis of the parts will not tell you who, or what, is organizing the flock as a whole, precisely because, now that we have isolated the individual starlings from one another, there is no more flock to study. There is no more complex whole, just a stack of parts.

This is the scientific dilemma which, thirty or forty years ago, led a small group of slightly out-of-mainstream scientists to begin focusing all of their attention on the phenomenon of complexity—what complex systems are and how they come about. They went so far as to set up a new institute for the study of complexity; located in New Mexico, it's called the Santa Fe Institute. Participating members are intentionally drawn, not from any one particular science, but rather from a variety of disciplines, each of which can bring its own examples to the table of complex systems that seem to just come together spontaneously out of simpler parts, thereby becoming something more than the sum of their parts, in the sense of engaging in complex, coordinated behaviors that none on the individual parts could have engaged in alone.

So, what have these scientists learned? Well, their work is still ongoing, and much of it is conducted within a highly technical, mathematical framework that is utterly impenetrable to lay readers like me. Nevertheless, they have managed to articulate a few basic principles that all of us can grasp, including an answer to the basic question of what exactly a complex system is. Complex systems have three defining characteristics. First, such a system will consist of a very large number of component parts. If you catch three ants, put them in a jar and feed them, you may or may not be able to keep them alive. But however they may interact with one another, they will not form a colony, nor any other sort of complex system. There are simply not enough individuals, nor enough interactions between individuals, for any sort of complexity to arise. Second, while a complex system will be composed of a large number of constituent parts, these parts will typically be quite simple in themselves. More specifically, each part, or each individual, will act in accord with just a few simple rules. It appears that individual starlings, for instance, may well navigate through the sky by means of just two simple rules:

1. If you see some insects in front of you, fly towards them.
2. If you see nothing but birds in front of you, follow the bird whose tail you're on.

With everyone following these two rules, we can understand how the flock would stay together as a flock, even as it performs a series of intricate pirouettes. One of the birds flying towards the front of the flock may happen to spot a swarm of insects, so following Rule 1, it takes off after them. This "leader" does not issue any commands to the rest of the flock, nor—presumably—does it even think about what the birds behind it are doing. But, having no other birds in front of it, it cannot follow Rule 2 at the moment, so it just observes Rule 1, and heads for any insects it sees. The birds behind it, meanwhile, cannot see much of anything besides the tails of other birds, so they just play follow the leader and observe Rule 2. And thus the entire flock stays together, even as it is darts and dodges around the sky.

The beauty of this arrangement is that the entire flock keeps flying through swarms of tasty insects, and thus everybody gets something to eat, even though the birds in back have not been spotting any insects, and even though the birds in front have not been trying to feed their slower companions. Everybody just instinctively follows two simple rules, and a coordinated, productive behavior on the part of the flock as a whole emerges. And this points to the third defining characteristic of complex systems: emergent behaviors, or more simply, emergence. As the system's numerous component parts act in accord with a few relatively simple governing rules, the entire group begins to behave in more of a complex, coordinated fashion, almost as if it were a single entity. This new, complex behavior is not dictated from on high, nor is it planned out nor directed by any of the group's members. The complex behavior just…emerges. It just happens. In this case, the whole flock just begins steering itself towards food sources that will feed the entire group, even though the food is spotted by only a small number of individual starlings.

Sticking with the ever-important quest for food, the ant colony gives us an even more elegant example of how individuals observing a few simple rules can generate a complex, yet highly useful, behavior on the part of the group as a whole. In the ant world, again, it is worker ants who are charged with collecting food, and research has shown that they instinctively follow a set of rules which looks something like the following:

1. Walk away from the anthill in any direction you please.
2. As you walk along, use your feelers to "sniff" for food.
3. If you do catch a whiff of food, walk towards the food, and when you get there, lay down a strong-smelling pheromone, then pick up as much food as you can carry and haul it back to the anthill.
4. If you catch a whiff of pheromone, start walking in that direction, then go back to Rule 2. Resume sniffing for food, that is, and when you encounter it, lay down some pheromone of you own, before picking up as much food as you can carry and hauling it back to the anthill.

So what happens when these rules are put into effect? At the beginning of the day, all of the worker ants set out in different random directions. None of them is in charge. None of them has a plan for how they will collect enough food to sustain the colony for a day. None of them even knows where any food is. But then, off in one direction, a couple of ants happen to sniff out a rotting leaf. They lay down their pheromone—which smells even stronger than the leaf—then pick up a chunk of leaf and head back to the anthill. A few more ants pick up the scent of the pheromone, so they change course and head in that direction. When they encounter the leaf, they lay down some pheromone of their own before grabbing a chunk of leaf and heading home. By now, the smell of the pheromone marker is growing much stronger, so even more ants will pick it up from even farther away; they come and make their own contribution to the marker before grabbing a piece of leaf. And so the whole thing just snowballs, until so many ants have been attracted that the whole leaf has been carried back to the anthill, and the colony has been sustained for another day.

If we step back to view this activity from a distance—back so far that we cannot make out any individual ants, but just see splotches of black where many ants are concentrated—it will look like the colony itself is behaving intentionally, stretching out a tentacle to grasp the one leaf in its immediate proximity. As we know, however, neither the colony, itself, nor any of its members are directing this action. Each ant is just following its own few, simple rules. But somehow, a complex, coordinated behavior on the part of the group as a whole just starts to emerge.

So that is what "emergence" means, in the wonky, scientific use of term. Emergence happens whenever a large number of relatively simple parts, each following a small number of relatively simple rules, comes together to form a whole that is more than the sum of its parts, in the sense that it begins acting as a unified group in ways that are more complex than the behaviors of its constituent parts. When you think about it, there are at least two mind-blowing things about this phenomenon of emergence. The first, mentioned several times already, is that throughout this process of emergence, no one is driving the bus. No one is directing traffic. No one sits down and designs the complex system, or plans out the complex behavior. It all just… *happens*. It does not happen by magic. Once we understand how ants go about hunting leaves, there is a perfect logic to the system they have developed, doubtless means of trial and error over the course of millions of years. But even though we can grasp how it would happen, it is still mind-blowing that a bunch of ants would manage to stumble across this ingenious, collective behavior that none of them alone could possibly even understand.

The second mind-blowing thing about emergence is that *this sort of thing happens all the time*. Nature, when you think about it, is just one emergence after another. Indeed, much of nature is one layer of emergent behavior resting on top of another, where the complex wholes formed out of simple parts on one level themselves come together and as parts to form even more complex wholes on the next level. Amino acids come together to form proteins, proteins come together to form cells, cells come together to form tissues, tissues come together to form organs, organs come together to form organisms, organisms come together to form species, species come together to form habitats, habitats come together to form—our world. In each of these instances, on each of these levels of being, new complex wholes emerge out of simpler parts, with each level being defined by an emergent behavior that is increasingly complex and sophisticated.

But enough of the wonkiness. What does this all have to do with spirituality? Well, here's my take. Some of you may have been here a few months ago when I spoke about the progressive worldview. I argued that being a progressive, in the very broadest of senses, means viewing the whole universe as making gradual progress over time—viewing the universe as having a bias in favor of progress. I further argued that progress can be defined, again in the most general terms, as a movement from simplicity towards greater complexity. When formless gas clouds coalesce into stars and planets, this is a movement from simplicity towards increased complexity. So, too, is the evolution from bacteria to lungfish to amphibians to mammals, and finally to human beings. We see this same movement in the human world, when small family bands begin organizing themselves into larger tribes, then into city states, then finally into nation states, some of which begin to govern themselves in accord with such universalistic principles as the ideal of universal human rights. What the concept of emergence adds to the progressive worldview is a recognition that, when nature moves in the direction from simplicity towards complexity, it does not usually do so in smooth, linear fashion. Nature rather tends to make progress in leaps, jumping from one level to the next, or rather building each new level upon the last, with each level defined by an emergent behavior that springs from the interactions of the many simpler parts on the level below.

As UU's, one of our most cherished principles is the seventh, by which we proclaim our respect the interdependent web of all existence, of which we are all a part. What the concept of emergence teaches us is that this interdependent web is not static. The world was not created with this interdependent web already in place. The world rather began with the simplicity of a massive fireball, a huge blast of energy racing apart from itself, with nothing yet differentiated from anything else. But ever since that time, nature has been going through one emergence after the next, the raw energy of the Big Bang coalescing into subatomic particulars, these particles coming together to form atoms, atoms forming molecules, molecules forming stars and planets, stars and planets forming stellar systems and galaxies, and the raw materials on at least one of these planets coming together to form—through a very long series of emergences—life, and ultimately human life. And thus, over time, as the emergent systems have gotten larger and larger, and ever more all-encompassing, the universe has grown, not just more complex, but ever more interwoven, ever more of an interdependent web. This ongoing process of weaving the world together is so breathtakingly elegant that some of us may conclude it must be the work of a transcendent God, a designer and director who stands outside the universe and orchestrates the progress going on within it. That is fine; there is a real logic to this belief. But the amazing thing that the young science of complexity has taught us is that, in every instance of emergence that scientists have yet studied, no outside intelligence has turned out to be necessary to explain it. On the contrary, example after example has shown that when relatively simple parts come together under the right conditions, each following its own simple rules, a complex, collective behavior very often emerges on its own.

And thus, for many of us who identify as spiritual progressives, this pulsing, creative movement forward *is* God, whether we want to call it God, or "the life force of the universe," or anything else. Whatever the label, we are all products of this creative, interweaving force. We are all products of countless emergences. And perhaps, through our actions, we can help some new, as-yet-unforeseen structures to emerge, thereby weaving a few more strands into the interconnected, interdependent web of all existence. May we truly honor and respect this web, of which we are all integral, dynamic parts.