CARL SAGAN

THE VARIETIES OF SCIENTIFIC EXPERIENCE

A PERSONAL VIEW OF THE SEARCH FOR GOD

EDITED BY ANN DRUYAN

Contents

Editor's Introduction

Carl Sagan was a scientist, but he had some qualities that I associate with the Old Testament. When he came up against a wall—the wall of jargon that mystifies science and withholds its treasures from the rest of us, for example, or the wall around our souls that keeps us from taking the revelations of science to heart—when he came up against one of those topless old walls, he would, like some latter-day Joshua, use all of his many strengths to bring it down.

As a child in Brooklyn, he had recited the Hebrew V'Ahavta prayer from Deuteronomy at temple services: "And you shall love the Lord your God with all your heart, with all your soul, with all your might." He knew it by heart, and it may have been the inspiration for him to first ask, What is love without understanding? And what greater *might* do we possess as human beings than our capacity to question and to learn?

The more Carl learned about nature, about the vastness of the universe and the awesome timescales of cosmic evolution, the more he was uplifted.

Another way in which he was Old Testament: He couldn't live a compartmentalized life, operating on one set of assumptions in the laboratory and keeping another, conflicting set for the Sabbath. He took the idea of God so seriously that it had to pass the most rigorous standards of scrutiny.

How was it, he wondered, that the eternal and omniscient Creator described in the Bible could confidently assert so many fundamental misconceptions about Creation? Why would the God of the Scriptures be far less knowledgeable about nature than are we, newcomers, who have only just begun to study the universe? He could not bring himself to overlook the Bible's formulation of a flat, six-thousand-year-old earth, and he found especially tragic the notion that we had been created separately

from all other living things. The discovery of our relatedness to all life was borne out by countless distinct and compelling lines of evidence. For Carl, Darwin's insight that life evolved over the eons through natural selection was not just better science than Genesis, it also afforded a deeper, more satisfying *spiritual* experience.

He believed that the little we do know about nature suggests that we know even less about God. We had only just managed to get an inkling of the grandeur of the cosmos and its exquisite laws that guide the evolution of trillions if not infinite numbers of worlds. This newly acquired vision made the God who created *the* World seem hopelessly local and dated, bound to transparently human misperceptions and conceits of the past.

This was no glib assertion on his part. He avidly studied the world's religions, both living and defunct, with the same hunger for learning that he brought to scientific subjects. He was enchanted by their poetry and history. When he debated religious leaders, he frequently surprised them with his ability to out-quote the sacred texts. Some of these debates led to longstanding friendships and alliances for the protection of life. However, he never understood why anyone would want to separate science, which is just a way of searching for what is true, from what we hold sacred, which are those truths that inspire love and awe.

His argument was not with God but with those who believed that our understanding of the sacred had been completed. Science's permanently revolutionary conviction that the search for truth never ends seemed to him the only approach with sufficient humility to be worthy of the universe that it revealed. The methodology of science, with its error-correcting mechanism for keeping us honest in spite of our chronic tendencies to project, to misunderstand, to deceive ourselves and others, seemed to him the height of spiritual discipline. If you are searching for sacred knowledge and not just a palliative for your fears, then you will train yourself to be a good skeptic.

The idea that the scientific method should be applied to the deepest of questions is frequently decried as "scientism." This

charge is made by those who hold that religious beliefs should be off-limits to scientific scrutiny—that beliefs (convictions without evidence that can be tested) are a sufficient way of knowing. Carl understood this feeling, but he insisted with Bertrand Russell that "what is wanted is not the will to believe, but the desire to find out, which is the exact opposite." And in all things, even when it came to facing his own cruel fate—he succumbed to pneumonia on December 20, 1996, after enduring three bone-marrow transplants—Carl didn't want just to believe: He wanted to know.

Until about five hundred years ago, there had been no such wall separating science and religion. Back then they were one and the same. It was only when a group of religious men who wished "to read God's mind" realized that science would be the most powerful means to do so that a wall was needed. These men—among them Galileo, Kepler, Newton, and, much later, Darwin—began to articulate and internalize the scientific method. Science took off for the stars, and institutional religion, choosing to deny the new revelations, could do little more than build a protective wall around itself.

Science has carried us to the gateway to the universe. And yet our conception of our surroundings remains the disproportionate view of the still-small child. We are spiritually and culturally paralyzed, unable to face the vastness, to embrace our lack of centrality and find our actual place in the fabric of nature. We batter this planet as if we had someplace else to go. That we even do science is a hopeful glimmer of mental health. However, it's not enough merely to accept these insights intellectually while we cling to a spiritual ideology that is not only rootless in nature but also, in many ways, contemptuous of what is natural. Carl believed that our best hope of preserving the exquisite fabric of life on our world would be to take the revelations of science to heart.

And that he did. "Every one of us is, in the cosmic perspective, precious," he wrote in his book *Cosmos.* "If a human disagrees with you, let him live. In a hundred billion galaxies you will not find another." He lobbied NASA for years

to instruct *Voyager 2* to look back to Earth and take a picture of it from out by Neptune. Then he asked us to meditate on that image and see our home for what it is—just a tiny "pale blue dot" afloat in the immensity of the universe. He dreamed that we might attain a spiritual understanding of our true circumstances. Like a prophet of old, he wanted to arouse us from our stupor so that we would take action to protect our home.

Carl wanted us to see ourselves not as the failed clay of a disappointed Creator but as *starstuff,* made of atoms forged in the fiery hearts of distant stars. To him we were "starstuff pondering the stars; organized assemblages of 10 billion billion billion atoms considering the evolution of atoms; tracing the long journey by which, here at least, consciousness arose." For him science was, in part, a kind of "informed worship." No single step in the pursuit of enlightenment should ever be considered sacred; only the search was.

This imperative was one of the reasons he was willing to get into so much trouble with his colleagues for tearing down the walls that have excluded most of us from the insights and values of science. Another was his fear that we would be unable to keep even the limited degree of democracy we have achieved. Our society is based on science and high technology, but only a small minority among us has even a superficial understanding of how they work. How can we hope to be responsible citizens of a democratic society, informed decision makers regarding the inevitable challenges posed by these newly acquired powers?

This vision of a critically thoughtful public, awakened to science as a way of thinking, impelled him to speak at many places where scientists were not usually found: kindergartens, naturalization ceremonies, an all-black college in the segregated South of 1962, at demonstrations of nonviolent civil disobedience, on the *Tonight* show. And he did this while maintaining a pioneering, astonishingly productive, fearlessly interdisciplinary scientific career.

He was especially thrilled to be invited to give the Gifford Lectures on Natural Theology of 1985 at the University of

Glasgow. He would be following in the footsteps of some of the greatest scientists and philosophers of the last hundred years—including James Frazer, Arthur Eddington, Werner Heisenberg, Niels Bohr, Alfred North Whitehead, Albert Schweitzer, and Hannah Arendt.

Carl saw these lectures as a chance to set down in detail his understanding of the relationship between religion and science and something of his own search to understand the nature of the sacred. In the course of them, he touches on several themes that he had written about elsewhere; however, what follows is the definitive statement of what he took pains to stress were only his personal views on this endlessly fascinating subject.

At the beginning of each Gifford Lecture, a distinguished member of the university community would introduce Carl and marvel at the need for still more additional halls to accommodate the overflow audience. I have been careful not to change the meaning of anything Carl said, but I have taken the liberty of editing out those gracious introductory remarks as well as the hundred or more notations on the audio transcripts that merely say "[Laughter]."

I ask the reader to keep in mind at all times that any deficiencies of this book are my responsibility and not Carl's. Despite the fact that the unedited transcripts reveal a man who spoke extemporaneously in nearly perfect paragraphs, a collection of lectures is not exactly the same thing as a book. This is especially true when the Pulitzer Prize–winning author in question never published anything without combing at least twenty or twenty-five iterations of every manuscript for error or stylistic infelicity.

There was plenty of laughter during these lectures, but also the kind of pin-drop silence that comes when the audience and the speaker are united in the thrall of an idea. The extended dialogues in some of the question-and-answer periods capture a sense of what it was like to explore a question with Carl. I attended every lecture, and more than twenty years later what remains with me was his extraordinary combination of

principled, crystal-clear advocacy coupled with respect and tenderness toward those who did not share his views.

The American psychologist and philosopher William James gave the Gifford Lectures in the first years of the twentieth century. He later turned them into an extraordinarily influential book entitled *The Varieties of Religious Experience,* which remains in print till this day. Carl admired James's definition of religion as a "feeling of being at home in the Universe," quoting it at the conclusion of *Pale Blue Dot,* his vision of the human future in space. The title of the book you hold in your hands is a tip of the hat to the illustrious tradition of the Gifford Lectures. My variation on James's title is intended to convey that science opens the way to levels of consciousness that are otherwise inaccessible to us; that, contrary to our cultural bias, the only gratification that science denies to us is deception. I hope it also honors the breadth of searching and the richness of insight that distinguished Carl Sagan's indivisible life and work. The varieties of his scientific experience were exemplified by oneness, humility, community, wonder, love, courage, remembrance, openness, and compassion.

In that same drawer where the transcript of these lectures was rediscovered, there was a sheaf of notes intended for a book we never had the chance to write. Its working title was *Ethos,* and it would have been our attempt to synthesize the spiritual perspectives we derived from the revelations of science. We collected filing cabinets' worth of notes and references on the subject. Among them was a quotation Carl had excerpted from Gottfried Wilhelm Leibniz (1646–1716), the mathematical and philosophical genius, who had invented differential and integral calculus independently of Isaac Newton. Leibniz argued that God should be the wall that stopped all further questioning, as he famously wrote in this passage from *Principles of Nature and Grace:*

"Why does something exist rather than nothing? For 'nothing' is simpler than 'something.' Now this sufficient reason for the existence of the universe…which has no need of any

other reason…must be a necessary being, else we should not have a sufficient reason with which we could stop."

And just beneath the typed quote, three small handwritten words in red pen, a message from Carl to Leibniz and to us: "*So don't stop.*"

• ANN DRUYAN

Ithaca, New York

March 21, 2006

Author's Introduction

In these lectures I would like, following the wording of the Gifford Trust, to tell you something of my views on what at least used to be called natural theology, which, as I understand it, is everything about the world not supplied by revelation. This is a very large subject, and I will necessarily have to pick and choose topics. I want to stress that what I will be saying are my own personal views on this boundary area between science and religion. The amount that has been written on the subject is enormous, certainly more than 10 million pages, or roughly 10^{11} bits of information. That's a very low lower limit. And nevertheless no one can claim to have read even a tiny fraction of that body of literature or even a representative fraction. So it is only in the hope that much that has been written is unnecessary to be read that one can approach the subject at all. I'm aware of many limitations in the depth and breadth of my own understanding of both subjects, and so ask your indulgence. Fortunately, there was a question period after each of the Gifford Lectures, in which the more egregious of my errors could be pointed out, and I was genuinely delighted by the vigorous give-and-take in those sessions.

Even if definitive statements on these subjects were possible, what follows is not such. My objective is much more modest. I hope only to trace my own thinking and understanding of the subject in the hopes that it will stimulate others to go further, and perhaps through my errors—I hope not to have made many, but it was inevitable that I would—new insights will emerge.

• CARL SAGAN

Glasgow, Scotland

October 14, 1985

THE VARIETIES
of
SCIENTIFIC EXPERIENCE

One

NATURE AND WONDER: A RECONNAISSANCE OF HEAVEN

The truly pious must negotiate a difficult course between the precipice of godlessness and the marsh of superstition.
• Plutarch •

Certainly both extremes are to be avoided, except what are they? What is godlessness? Does not the concern to avoid the "precipice of godlessness" presuppose the very issue that we are to discuss? And what exactly is superstition? Is it just, as some have said, other people's religion? Or is there some standard by which we can detect what constitutes superstition?

For me, I would say that superstition is marked not by its pretension to a body of knowledge but by its method of seeking truth. And I would like to suggest that superstition is very simple: It is merely belief without evidence. The question of what constitutes evidence in this interesting subject, I will try to address. And I will return to this question of the nature of evidence and the need for skeptical thinking in theological inquiry.

The word "religion" comes from the Latin for "binding together," to connect that which has been sundered apart. It's a very interesting concept. And in this sense of seeking the deepest interrelations among things that superficially appear to be sundered, the objectives of religion and science, I believe, are identical or very nearly so. But the question has to do with the reliability of the truths claimed by the two fields and the methods of approach.

By far the best way I know to engage the religious sensibility, the sense of awe, is to look up on a clear night. I believe that it is very difficult to know who we are until we understand where and when we are. I think everyone in every culture has felt a sense of awe and wonder looking at the sky. This is reflected throughout the world in both science and religion. Thomas Carlyle said that wonder is the basis of worship. And Albert Einstein said, "I maintain that the cosmic religious feeling is the strongest and noblest motive for scientific

research.” So if both Carlyle and Einstein could agree on something, it has a modest possibility of even being right.

Here are two images of the universe. For obvious reasons they concentrate not on the spaces in which there is nothing but on the locales in which there is something. It would be very dull if I simply showed you image after image of darkness. But I stress that the universe is mainly made of nothing, that something is the exception. Nothing is the rule. That darkness is a commonplace; it is light that is the rarity. As between darkness and light, I am unhesitatingly on the side of light (especially in an illustrated book). But we must remember that the universe is an almost complete and impenetrable darkness and the sparse sources of light, the stars, are far beyond our present ability to create or control. This prevalence of darkness, both factually and metaphorically, is worth contemplating before setting out on such an exploration.

fig. 1

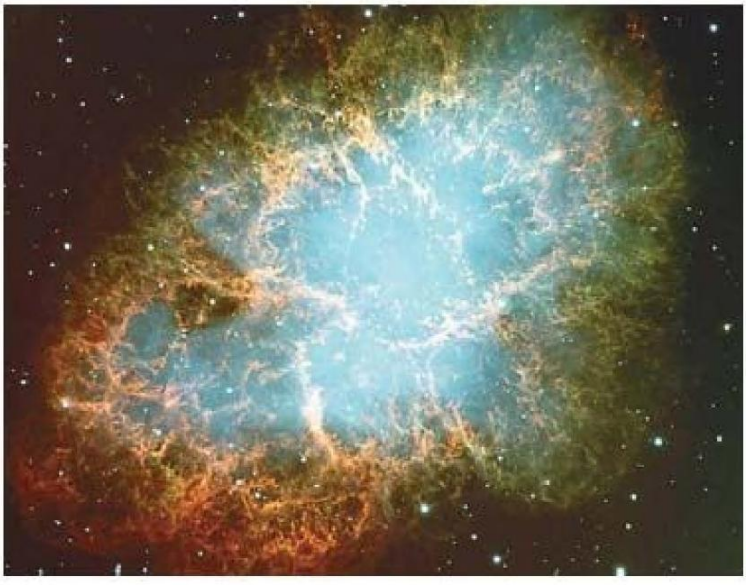


fig. 2

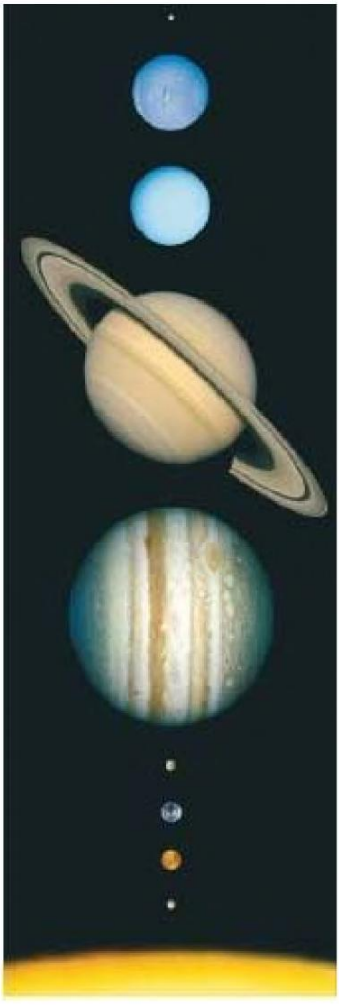


fig. 3

This image is intended for orientation. It is an artist's impression of the solar system, in which the sizes of the objects but not their relative distances are to scale. And you can see that there are four large bodies other than the Sun, and the rest is debris. We live on the third piece of debris from the Sun; a tiny world of rock and metal with a thin patina—a veneer—of organic matter on the surface, a tiny fraction of which we happen to constitute.

This picture was made by Thomas Wright of Durham, who published an extraordinary book in 1750, which he quite properly called *An Original Theory or New Hypothesis of the Universe.* Wright was, among other things, an architect and a draftsman. This picture conveys a remarkable sense, for the first time, of looking at the solar system and beyond, to scale. What you can see here is the Sun, and to scale to the size of the Sun is the distance to the orbit of Mercury. Then the planets Venus, Earth, Mars, Jupiter, and Saturn—the other planets were not known in his time—and then, in a wonderful attempt, here is the solar system, the planets we talked about, all in that central dot and a rosette to represent the cometary orbits known in his time. He did not go very far beyond the present orbit of Pluto. And then he imagined, a large distance away, the nearest star then known, Sirius, around which he did not quite have the courage to put another rosette of cometary orbits. But there was the clear sense that our system and the systems of other stars were similar.

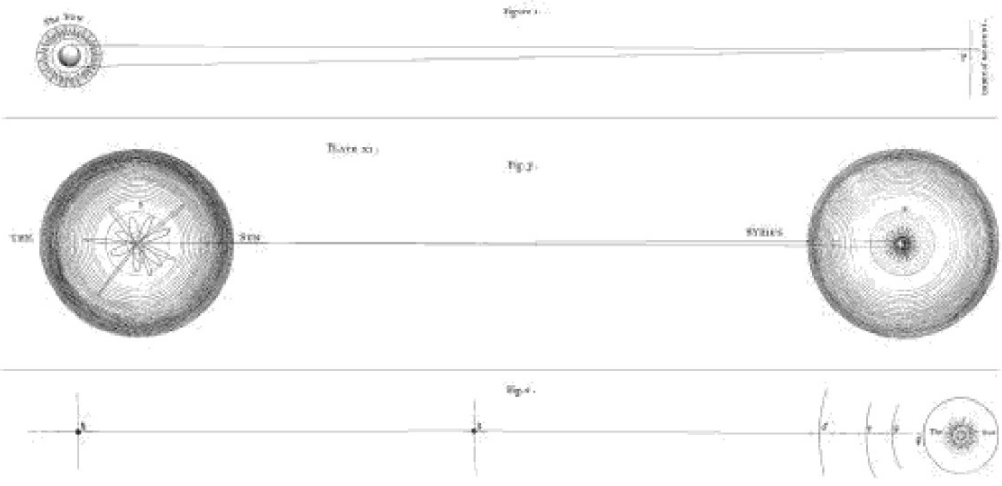


fig. 4

Here at upper left is the first of four modern illustrations attempting to show just the same thing, in which we see the Earth on its orbit and the other inner planets. Each little dot is intended to represent a fraction of the plethora of small worlds called asteroids. Beyond them is the orbit of Jupiter. And the distance from the Earth to the Sun represented by the scale bar up at the top is called an astronomical unit. This is the first introduction—there will be many of them that I will talk about—of a kind of geocentric or anthropocentric arrogance with which all of the human attempts to look at the cosmos seem to be infected. The idea that an astronomical unit by which we measure the universe has to do with the Earth's distance from the Sun is clearly a human pretension. But since it is deeply embedded in astronomy, I will continue to use the word.

At upper right we see that the previous picture is wrapped in a small square in the middle. Here we have a scale of ten astronomical units. We cannot make out the orbits of the inner planets, including the Earth, on this scale. But we can see the orbits of the giant planets Jupiter, Saturn, Uranus, Neptune, as well as Pluto.

At lower right the previous picture is in a small square, and we now have a scale of a hundred astronomical units. Here's a comet—there are many—with a highly eccentric orbit.

Another increase in scale by a factor of ten and we have the picture at lower left. And here the gray shading is intended to represent the inner boundaries of the Oort Cloud of roughly a trillion comets—cometary nuclei—that surround the Sun and extend to the boundaries of interstellar space.

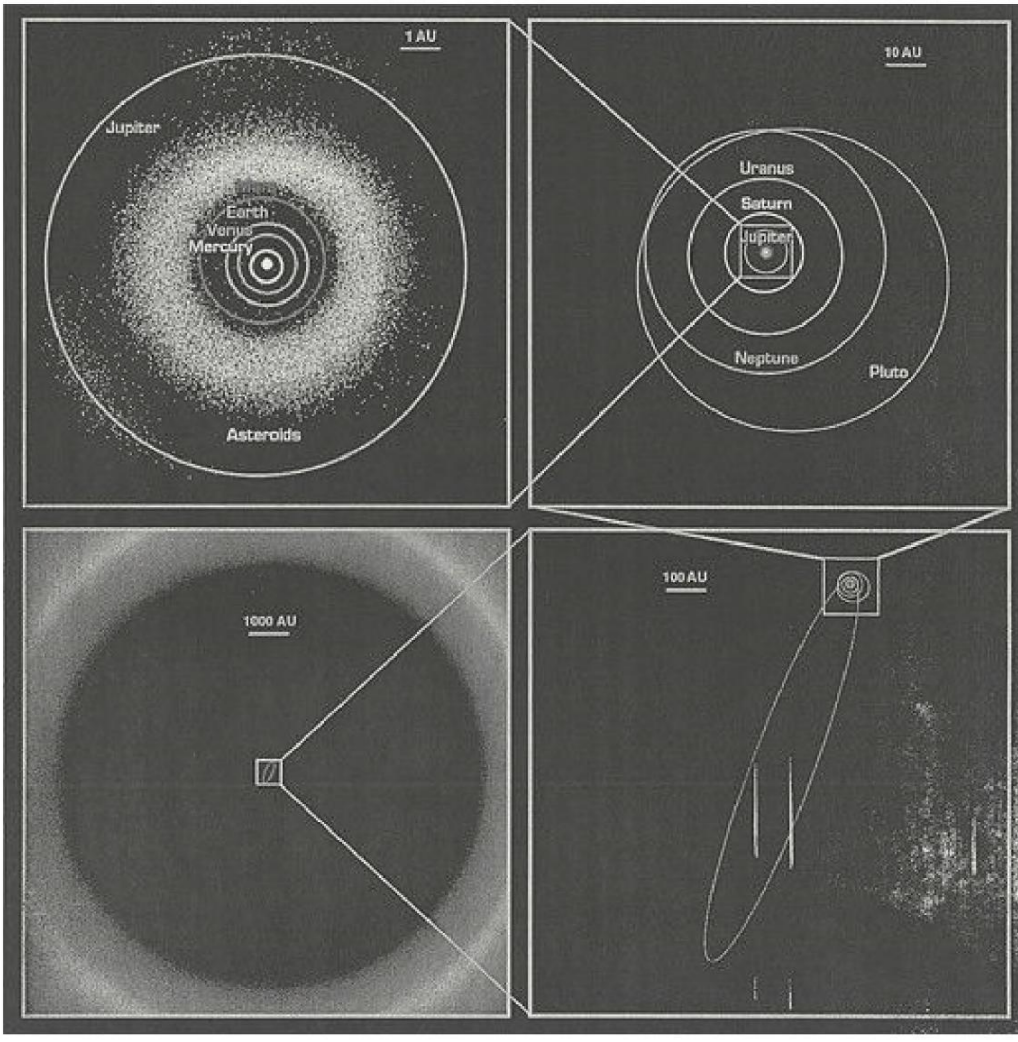
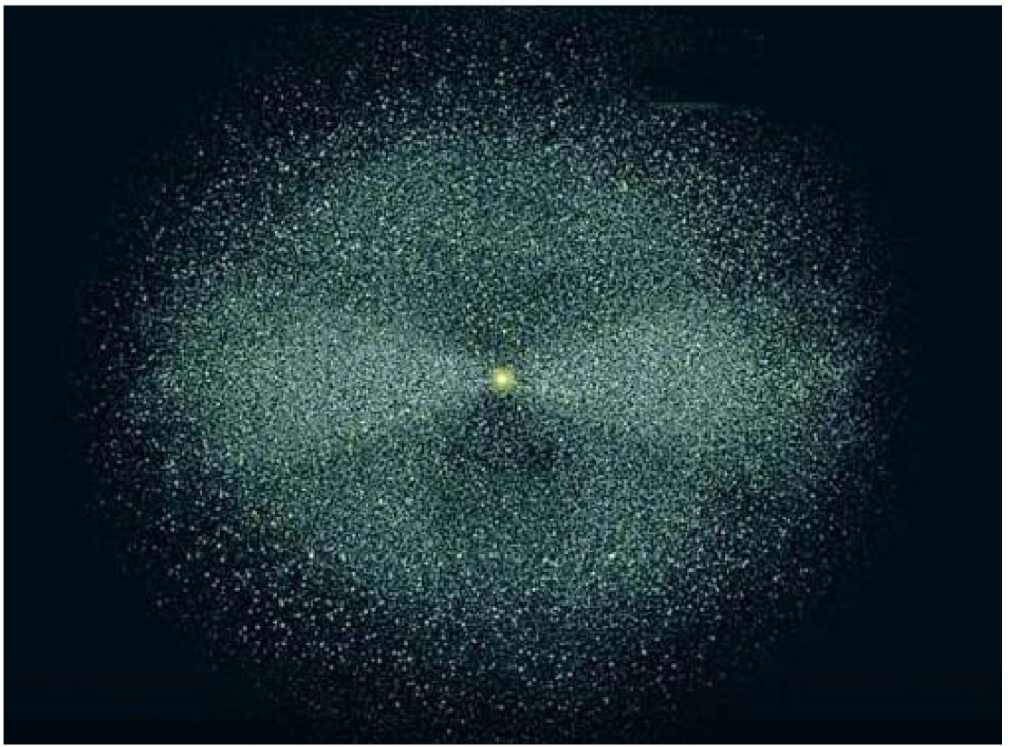


fig. 5

fig. 6



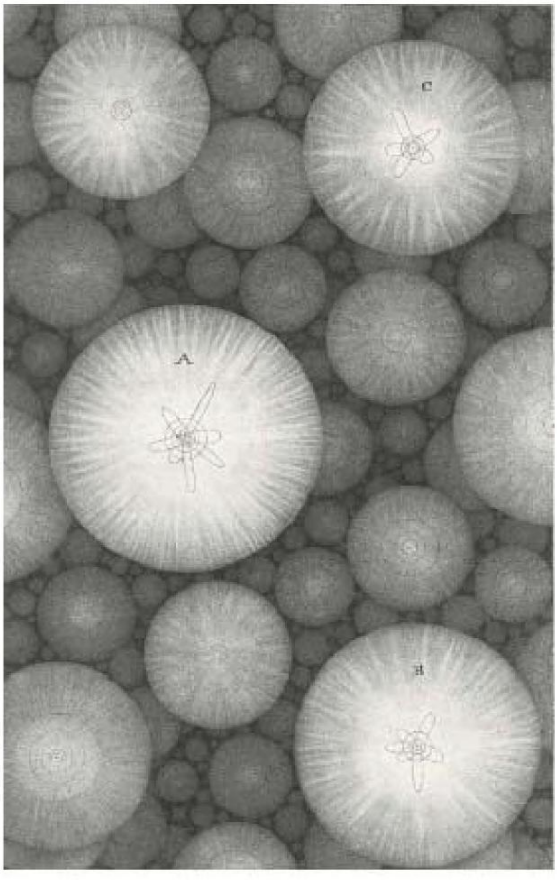


fig. 7

fig. 8

This is the Pleiades, a set of young stars that have been born only recently and are still enveloped in their cocoons of interstellar gas and dust.

This is one of the many nebulae, large clouds of interstellar gas and dust. Just to be clear what we are seeing here, there is a sprinkling of foreground stars, behind which is a cloud of glowing interstellar hydrogen—that's the red stuff. The darkness is not the absence of stars; it is simply a place where the dark material prevents you from seeing the stars behind. It is in dense concentrations of this dark interstellar material that new stars and, we now are beginning to see, new planetary systems are in the process of being born.

fig. 9

Here is a still more explosive and dangerous event. This is the Veil Nebula. It is a supernova remnant, a star that has violently exploded, and any life on any planet that existed around the star that exploded, the supernova, would surely have been destroyed in this explosion. Even ordinary stars like the Sun have a sequence of events late in their history, which mean big trouble for inhabitants of any planets that they might have.

Some 5 or 6 or 7 billion years from now, the Sun will become a red giant star and will engulf the orbits of Mercury and Venus and probably the Earth. The Earth then would be inside the Sun, and some of the problems that face us on this particular day will appear, by comparison, modest. On the other hand, since it is 5,000 or more million years away, it is not our most pressing problem. But it is something to bear in mind. It has theological implications.

fig. 11

fig. 12

There are a huge number of stars. Especially in the center of the galaxy, in the direction of the constellation Sagittarius, the sky is rippling with suns, altogether a couple of hundred thousand million suns, making up the Milky Way Galaxy. As far as we can tell, the average star is in no major way different from the Sun. Or, put another way, the Sun is a reasonably typical star in the Milky Way Galaxy, nothing to call our attention to it. If you had stepped a little bit back and included the Sun in this picture, you would not be able to tell whether it was that one right there or that one right over there, maybe, in the top right-hand corner.

It would be very good to have a photograph of the Milky Way Galaxy taken from an appropriate distance, but we have not yet sent cameras to that distance and so the best we can do for now is to show a photograph of a galaxy like our own, and this is, in fact, the nearest spiral galaxy like our own, M31 in the constellation Andromeda. And again we are looking at stars in the foreground within the Milky Way Galaxy, through which we are seeing M31 and two of its satellite galaxies.

Now, imagine that this is our galaxy. We are looking at a great concentration of stars in the center, so close together that we cannot make out individual ones. We see these spiral lanes of dark gas and dust in which star formation is mainly occurring. If this were the Milky Way Galaxy, where would the Sun be? Would it be in the center of the galaxy, where things are clearly important, or at least well lit? The answer is no. We would be somewhere out in the galactic boondocks, the extreme suburbs, where the action isn't. We are situated in a very unremarkable, unprepossessing location in this great Milky Way Galaxy. But, of course, it is not the only galaxy. There are many galaxies, a very large number of galaxies.