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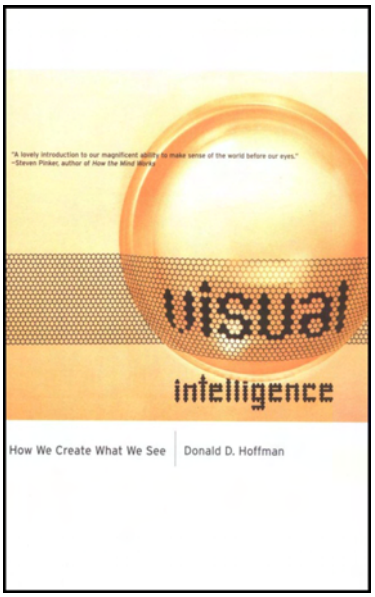

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Visual Intelligence: How We Create What We See

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Chapter 8 (pp. 185–199)
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Peeking Behind the Icons

My wrist didn't hurt when I spiked it, and my opponents just laughed when it hit them in the head. I was playing virtual volleyball with a dozen players, and many spectators were waiting in line to get in the game. It was a popular attraction at the Virtual Reality Exhibit in the Los Angeles County Museum of Science and Industry.

By today's standards, that volleyball game was low tech; the ball and players appeared only in silhouette. Virtual reality has long since progressed from a futuristic curiosity in museums to a present and powerful force in medicine, education, architecture, and entertainment. Billions of dollars are at stake as companies position themselves in this burgeoning market and as evolving technologies create increasingly realistic virtual worlds.

Of course it's not technology per se that creates realistic virtual worlds. It's the customers, the ones paying their hard-earned cash, who are the real creators. Virtual reality is only possible because we, the customers, construct what we perceive.

We are the source of the stock cars we pass in a virtual drag race, the prospective stadium we scrutinize in a virtual architectural walk through, the molecules whose 3D shape we see and whose electric forces we feel in a virtual chemistry course, and the delicate, bleeding tissues we slice in a virtual open-heart surgery. The high tech displays cleverly prompt us to construct these scenes, and the more clever the prompting

the better scenes we can construct (and the more we're willing to pay). But the displays can only prompt, they can't construct the virtual realities for us. What makes one display more compelling than another is that it more fully engages the constructive processes of the customer.

But now let's use virtual reality for another purpose, as a metaphor to explore questions that have probably nagged you about the story on perceptual construction. Questions like these: if we each construct all we see, then why do we all see the same things? What is the relationship between "reality" and our constructions?

For concreteness, imagine that you've gone to your local arcade, and you're about to play the latest game of virtual volleyball with nine other players. Each of you gets a helmet that can immerse you in stereo sound and stereo images of high resolution. Each of you also gets a high-tech bodysuit that can incite sensations of pressure, light bumps, and other forms of force feedback. The helmets and bodysuits communicate, via radio signals, with a nearby supercomputer which hosts the software for virtual volleyball and numerous other virtual attractions. The arcade manager proudly tells you that the volleyball software occupies 100 gigabytes of memory, and represents hundreds of hacker-months of program development. Which is why, of course, this ten-minute game costs so much.

After you put on your helmet, you find yourself on a sandy beach with nine other players dressed not in the ugly high-tech bodysuits you saw just a moment ago, but in flattering bathing suits. You're surrounded by palms trees and blue skies, with light puffy clouds. You hear the soft screeching of gulls, and the gentle pounding of surf. You see an off-white volleyball lying before you on the sand, and a volleyball net already set up. Five players on the other side of the net, and four more on your side, are all anxious to play. You're first to serve, so you bend over and grab the volleyball.

This is no cheap plastic volleyball. It sports soft, high-quality leather that warms to the touch. You bounce it lightly on your wrist a couple times, and nod approvingly to the other players.

Then you serve and the fun begins. You and the others are soon completely absorbed as you dig, set, feint, and spike with abandon. This goes on for a few wonderful minutes.

Then, suddenly, you are plagued with philosophical worries about the game you're now playing. Between points, and in lulls in the action, question after question comes to mind. The first is this:

Are we all seeing and playing with the same volleyball?

It sure feels like you are. Just a moment ago you did a beautiful set, placing the ball in perfect position over the net, and then one of your teammates spiked that ball, that very same ball, to give your team a side out. So you must be seeing and playing with the same ball.

But you've been reading *Visual Intelligence,* and you remember that the phrase *what you*

see has both a phenomenal and a relational sense. In the phenomenal sense, what you see means "the way things look to you," "the way they visually appear to you," "the way you visually experience them." But in the relational sense it means "what you interact with when you look."

So you decide to ask the question in the phenomenal sense.

Are we all, in the phenomenal sense, seeing and playing with the same volleyball?

And here the answer seems plainly, No. You wear your own separate helmet with its own stereo display, as does each of the other players. Your display sprays a shower of photons onto your eyes. This shower engages the constructive genius of your visual system, which then constructs your volleyball experience. There is no volleyball experience in the shower of photons itself. That shower merely triggers you to construct your own volleyball experience. Similarly for each of the other players. So you each construct your own volleyball experience. Those experiences are not, as the philosophers would put it, "numerically identical," that is, one and the same. And therefore you and your teammates do not, in the phenomenal sense, see and play with the same volleyball.

You decide next to ask the question in the relational sense.

Do we all, in the relational sense, see and play with the same volleyball?

This one is more disturbing. What you interact with when you see that volleyball, or anything else right now, is a supercomputer with 100 gigabytes of software running on it. And your teammates interact with that same supercomputer and software. So "what you interact with when you look" is the same thing as what your teammates interact with when they look, namely the computer and its software. That means that the answer is yes: in the relational sense you all see and play with the same volleyball.

What's disturbing about this conclusion, though, is that circuits and software don't in any way resemble volleyballs. You've looked inside your PC, and you've done a little programming in your time, and you know without a doubt that none of this looks remotely like volleyballs. It feels strange to conclude that you all see the same volleyball because you all interact with the same circuits and software. That's not at all what you had in mind when you first thought that you were setting the same volleyball that your teammate then spiked.

Apparently, when you look at a volleyball or anything else, what you see in the phenomenal sense and what you see in the relational sense can be as different in nature as you like, as different as a soft leather ball on the one hand and intangible software and cold hard circuits on the other. Maybe even more different. There need be no resemblance.

If there's no resemblance, is there no relation at all? That can't be right either. For the volleyball experiences that you construct prove a useful guide for playing the computer's game, a guide that is quicker and more effective than poring over computer printouts. Computerphobes, who've never programmed and know nothing about re-

gisters or software, can put on the helmet and suit and, just by hitting the volleyball that they experience, alter those computer registers as deftly as the most inveterate hacker. Ignorance can be bliss.

There is a relationship then, in the normal case, between what you see in the phenomenal and relational senses. What you see in the phenomenal sense is a useful and simplified *interface* to what you see in the relational sense. It summarizes a myriad of complexities in a way that lets you interact with that complexity without tedium and distraction. What it provides you is indeed phenomenal — a phenomenal interface.

So the answer to your first question — *Are we seeing and playing with the same volleyball?* — is both yes and no. No, you each have constructed your own volleyball experiences. And yes, you each are interacting with the same hidden world of circuits and software. There are as many phenomenal volleyballs as there are players. There is only one relational volleyball, and it doesn't resemble a volleyball at all.

That first question took you to unexpected places, so you try another.

Is the volleyball still there when I don't look?

Again the answer depends on the volleyball. Your phenomenal volleyball is your construction. When you don't look you don't construct it. So the phenomenal volleyball *isn't there* when you don't look. However, the relational volleyball doesn't depend on your constructive powers for its existence. The relational volleyball is just the circuits and software. So the relational volleyball *is there* when you don't look. It just doesn't resemble a volleyball.

Is the volleyball an off-white color when I don't look?

The phenomenal volleyball isn't there when you don't look, so it isn't off-white or any other color. Nor is it round or soft or leathery. The relational volleyball is circuits and software, and it isn't literally off-white either. There may be portions of the software whose intent is to spray photons on your eyes such that you will construct an off-white phenomenal volleyball. But this software isn't any color at all. And the color of the circuits is irrelevant to the color of the phenomenal volleyball. So the answer is no, for both the phenomenal and relational volleyballs. And this same answer holds for the shape, texture, motion, position in space, hardness or softness, and other such properties of the volleyball.

What causes me to see a volleyball?

Is it something that resembles a volleyball, something round and off-white and leathery? No. The only such thing here is the phenomenal volleyball, and it is the result, not the cause, of my perceptual constructions. So the only possible cause must be the relational volleyball, which doesn't resemble a volleyball at all.

Is the volleyball conscious? Does it have experiences?

The relational volleyball is just circuits and software. Although proponents of "strong" artificial intelligence (AI) grant that computers can be conscious, I see no need to grant

consciousness here. This computer doesn't simulate consciousness, it plays volleyball. Even if strong AI is true, it doesn't follow that this computer, and therefore this relational volleyball, is conscious.

The phenomenal volleyball is my construction. But from the fact that I am conscious, and that I construct the phenomenal volleyball, it doesn't follow that the phenomenal volleyball is itself conscious. I would need further, currently lacking, evidence to reach that conclusion. So I can't conclude that the phenomenal volleyball is conscious.

Are my teammates conscious?

The phenomenal teammates are, like the phenomenal volleyball, my constructions. If the phenomenal volleyball needn't be conscious, then why should my phenomenal teammates be conscious? What differentiates the two? For now, nothing of importance, so I can't conclude that my phenomenal teammates are conscious.

My relational teammates, like the relational volleyball, are circuits and software. But these circuits and software receive radio signals from my "real" teammates who are conscious, so that ultimately I interact with them. Thus the relational teammates are conscious, although my phenomenal ones are not.

Enough questions for the moment. The score is 14 to 13, and you're serving for the win, when time expires and your helmet goes blank. You return it and the body suit, and thank your teammates for a good game as you head for the exit.

The exit is teeming with volleyball accessories and memorabilia — sun glasses, tank tops, post cards — but the volleyballs catch your eye. They're the same off-white color as the virtual volleyball you just played with. You pick one up and bounce it. It's the same soft leather with the same texture as the virtual volleyball. In fact, phenomenally, they're identical. You gaze in admiration.

Then a question spoils the moment.

This phenomenal volleyball is identical to the one I just played with. What about the relational volleyballs? Are they identical?

The relational volleyball in the game was circuits and software. It seems unlikely, however, that the same is true for the volleyball you now have in hand. After all, volleyballs were around before computers and software. So the relational volleyball is not circuits and software. But then, what is it? Tough question. We'll come back to it.

The arcade has educational exhibits, and you try one called The Virtual Brain. You enter a small room crammed with high-tech equipment, put on a helmet and bodysuit, and a voice announces, "Welcome to the Virtual Brain. The brain you are about to see is your own. Through the miracles of modern technology, we can scan your brain and create images of its structure and activity. These images are, in every detail, what you would see if you removed your skull and looked at your own brain. If this prospect bothers you, you may leave now."

This prospect intrigues you, so you stay. The helmet display flashes on, and you see a

brain floating before you. You look around and realize that you and the brain are in a large vat filled with fluid. Also inside this vat are a host of high-tech devices — magnetic stimulators, electrodes, microscopes, surgical tools, and others.

The headphones continue, "This is your brain. Feel free to hold it, rotate it, and look at it from any angle you wish."

You reach out, gently grasp the brain, and look it over. A handsome specimen indeed.

"Neuroscience has revealed that different parts of your brain do different functions. If you'll just pick up the electrode to your right, you can explore this for yourself."

You pick up the electrode, and an arrow appears pointing to the back of the brain. "This part of your brain does vision. If you stimulate it with your electrode, our new proprietary Noninvasive Magnetic Brain Stimulator, or NIMBS, will stimulate the corresponding part of your own brain, so that you can experience for yourself what it does. Go ahead."

You gingerly touch the electrode to the back of the brain on the right side, and press a button labeled "Stimulate" on the handle of the electrode. Immediately you see a flash of light, up and to the left. As you move the electrode up the back of the brain, this flash of light moves systematically across your visual field. You let go of the Stimulate button, and the flash disappears.

Then you try this on the left side of the brain in an area that the headphones have told you is "somatosensory cortex." As you stimulate the brain, you feel a tingling sensation in your right knee. As you move the electrode down the side of the brain, the tingling sensation moves up your body.

As you stimulate other areas of the brain, you have different experiences. A buzzing sound, the smell of smoke. One area makes your leg twitch.

"Now put away the electrode, and try the magnetic inhibitor on your left. This inhibits the electrical activity in a small region of your brain, and gives you an idea of what it would be like to lose that bit of your brain to a stroke."

An arrow pops up, pointing to a spot on the lower left side of your brain. You put the inhibitor there and push the "Inhibit" button. To your amazement, the color drains away from the right half of your visual field, leaving you seeing only shades of gray. You let go of the inhibitor button and, to your relief, color flows back into the right visual field.

The arrow moves back a little. You try the inhibitor there, and suddenly all motion stops in the right visual field. You wave your virtual hand in front of you. You see it move just fine when it's in the left visual field, but it jumps as if you were viewing it with a strobe light when it's in your right visual field.

Such demonstrations go on for the next ten minutes, educating you about the activities of individual neurons, synapses, neurotransmitters, neural networks, distributed processing, synchronous oscillations, receptive fields, topographic maps — all demon-

strated live on your own virtual brain.

When it's all over, the headphones conclude, "And so ends our tour of your brain. As you've seen for yourself, and as research in neuroscience has triumphantly confirmed, your brain creates all your conscious experiences. Your mind *is* what your brain does. Thank you and goodbye."

You slip off your helmet, in awe at the triumphs of neuroscience, and in awe at the complexity and creative power of your own brain. As you leave The Virtual Brain, its last pronouncements go around and around in your head, "*. . .* your brain creates all your conscious experiences. Your mind *is* what your brain does."

This sounds plausible enough, you think. But then those pesky questions start again.

Which brain creates all my conscious experiences? The phenomenal brain or the relational brain?

The brain you just experienced in The Virtual Brain was of course a phenomenal brain. Indeed, The Virtual Brain headphones told you that this phenomenal brain was indistinguishable from the phenomenal brain you would find if you opened up your skull.

So is it this phenomenal brain that creates all your conscious experiences? No. The phenomenal brain, with all its phenomenal neurons and synapses and neural networks, is your constructed experience, just like the phenomenal volleyball. If you don't look, it's not there. And if it's not there, it can't do anything. But you have conscious experiences even when you don't see your phenomenal brain. In fact, until just a few minutes ago, you had probably never seen your phenomenal brain. So the phenomenal brain can't be what constructs your conscious experience.

That leaves your relational brain. If it's true that your brain creates all your conscious experiences, then it must be your relational brain, not your phenomenal brain, which is the creator.

But what is your relational brain? Does it resemble your phenomenal brain? There's no reason to suppose it does. In fact, as we saw with the volleyball, there's no reason to suppose that the nature of the phenomenal brain in any way constrains the nature of the relational brain. Your phenomenal brain is simply a graphical interface that allows you to interact with your relational brain, whatever that relational brain might be. And all that's required of a graphical interface is that it be systematically related to what it represents. The relation can be as arbitrary as you wish, as long as it's systematic. The trash can icon on your computer screen is a graphical interface to software which can erase files on your computer disk. The trash can icon is systematically related to that erasing software, but the relation is arbitrary: the trash can icon doesn't resemble the erasing software in any way. It could be any color or shape you wish and still successfully do the job of letting you interact with the erasing software. It could be a pig icon or a toilette icon instead of a trash can icon. All that matters is the systematic connection.

A fascinating illustration of the arbitrary but systematic nature of the connection

between the phenomenal and relational realms is "synesthesia," a condition enjoyed by just ten people in a million, in which they experience by two separate senses what the rest of us experience by just one. One synesthete, a professor at the California Institute of Technology, told me that he heard distinct sounds for each shape he saw. Puffy clouds in the sky, for instance, sounded like "Putt, putt, putt." Another synesthete, studied by the neurologist Richard Cytowic, felt what he tasted. A squirt of Angostura bitters on his tongue led him to describe what he felt as follows: "It has the springy consistency of a mushroom, almost round, but I feel bumps and can stick my fingers into little holes in the surface. There are leafy tendril-like things coming out of the holes, about six of them. . ." Each different taste had, for him, a different feel. Mint, for instance, felt like smooth, cool, columns of glass. A given taste always had the same feel. That is, there was a systematic but arbitrary association between feels and tastes. Such associations endure basically unchanged for the life of the synesthete, as has been demonstrated by tests forty-six years apart on one synesthete.

Why should mint feel like cool columns of glass, and puffy clouds sound like "Putt, putt"? No good reason. Are columns of glass an intrinsically better representation of the true nature of mint than, say, sheets of ice? I would be hard pressed to justify one over the other. On what grounds would I make the judgment? Both are arbitrary. Columns of glass or sheets of ice would both work just fine, as long as the association was systematic and enduring.

But the same questions can be asked about the experiences the rest of us nonsynesthetes enjoy. Why should mint taste like mint and not, say, like vanilla? Our mint experience itself is just as arbitrary as a synesthete's experience of columns of glass. So are our experiences of colors, shapes, sounds, and smells. These experiences are systematically related to the relational world, but the relation is arbitrary. One can easily imagine that we would do just fine if our color experiences were inverted, so that reds looked green, blues looked yellow, and so on. If the inversion is systematic, we lose no information and therefore no abilities. One can also easily imagine such inversions in each of our other modes of experience. Indeed designers of virtual reality systems may soon take us into new virtual worlds where we experience, and perhaps learn to adapt to, just such inversions. A small step in this direction was taken in 1896 by George M. Stratton, who had volunteers wear prisms that make the world appear upside down. At first they find it hard to get along in the upside down world. But after consistently wearing the inverting prisms for a few days, they find that everything once again looks "normal" and that they can carry on their daily activities just fine. When the prisms are then removed, everything again looks upside down and it takes them some time to readjust. When the psychologist Jan Koenderink repeated this experiment, he saw individual objects or object parts turn right side up while the rest of his visual world still looked upside down. Eventually his whole visual world turned right side up. It's possible, then, to alter the arbitrary but systematic relationship between our phenomenal and relational worlds, and for us to adjust quickly and successfully to the new relationship.

So, returning to our brain example, the phenomenal brain that you saw in The Virtual Brain, and the phenomenal brains that neuroscientists study in their labs, are wonderful graphical interfaces and eminently worthy of study, but they are not the relational brain and they alone cannot determine the true nature of that relational brain. The relationship between the phenomenal brain and the relational brain is systematic and arbitrary, as arbitrary as the relation between mint and columns of glass.

Back now to the virtual reality arcade, where you decide to check out The Virtual Supercomputer, an exhibit which promises to reveal "the real power behind virtual reality."

You don a helmet and body suit. The helmet display flickers on, and you see, slowly rotating before you, a sleek steel box with a dozen flashing lights, and the label "MPC-9000" written in a slanting script. The headphones begin, "Welcome to The Virtual
Supercomputer. Here you will meet the real star of virtual reality, the key actor responsible for the success of Virtual Volleyball, Virtual Dogfighter and our other popular attractions. That star is the MPC-9000, the latest and fastest Massively Parallel Computer, boasting 9000 parallel central processing units, and delivering 100 teraflops of computing power. The MPC-9000 will now give you a tour of its inner self. The images you are about to see are, in every detail, precisely what you would see if you looked inside its steel case."

Two arrows appear, pointing to two buttons on opposite sides of the steel case. The headphones continue, "Push the two buttons indicated by the arrows, and remove the top of the case. Then remove its sides as well." You do so, and see a bewildering complexity of glistening metal, wires, cables, cubes, and other paraphernalia. For the next fifteen minutes you explore this complexity to your heart's content, using virtual magnifying glasses and virtual microscopes for a closer look. You're free to pull out individual cubes and cables, and to probe them with virtual electrodes while the headphones describe their functions. You learn that the MPC- 9000 is a sophisticated synthesis of gallium arsenide, optical, and even quantum computing, and that, unlike earlier MPCs whose circuits were fabricated in two dimensions, this one has circuits fabricated in three dimensions, giving it unprecedented speed and compactness. You also have a chance to look through virtual volumes of software printouts, one for The Virtual Volleyball, and one for each of the other arcade attractions.

When the fifteen minutes are up, the headphones announce, "This concludes our tour of The Virtual Supercomputer. The MPC-9000 is the reality behind virtual reality. The next time you fly a virtual fighter jet or spike a virtual volleyball, just remember, it's the circuits and software of the MPC-9000 that make it all possible. Thank you and good bye."

You remove your helmet and body suit, being duly impressed with the prowess of the MPC-9000, and having a better understanding of why the attractions cost so much. As you leave The Virtual Supercomputer, its final words of wisdom continue to echo in

your thoughts, "... it's the circuits and software of the MPC-9000 that make it all possible."

You can't help yourself. You have to ask the question.

Which circuits and software make it all possible? The phenomenal or the relational?

By now this question is easy. It's not phenomenal circuits and software that make it possible, say, to spike a virtual volleyball. It couldn't be. There need be no phenomenal circuits and software, for you or anyone else, when you spike the volleyball, so therefore phenomenal circuits and software can't be what makes that spiking possible.

The answer must be that it's the relational circuits and software that make it possible to play virtual volleyball. But of course this raises another question.

What are relational circuits and software?

We know that they needn't in any way resemble the phenomenal circuits and software that we experience. But what more can we say about them?

This raises a general and important question. If the relational realm needn't resemble the phenomenal, then what can we safely say about the nature of the relational realm?

Not much. However,we can propose theories and see how they stack up against our experiences. This is an intriguing enterprise, and one that has attracted lots of attention. There are now many theories of the relational realm that are compatible with all the evidence we have from the phenomenal realm.

These theories come in three basic kinds: *physicalism, idealism,* and *dualism.*

Physicalism proposes that the relational realm is mindless. There are many versions of this proposal. The one most influential, at present, proposes that the basic building blocks of the relational realm are the particles, fields, and other entities within the province of microphysics. The behavior of these entities is mindless, governed entirely by probabilistic laws.

Idealism proposes that the relational realm is made of minds. It may be one mind, as in Berkeley's proposal that it's the mind of God, or it may be many distinct and finite minds in interaction. In the latter case, the behavior of these minds has also been described by probabilistic laws.

Dualism proposes that the relational realm is made both of minds and mindless entities. There are probabilistic laws governing the minds, the mindless entities, and the interactions between the two.

These three theories disagree primarily on whether the relational realm is mindless. Physicalism says it is, idealism says it's not, and dualism says it's both. None of the three has, to date, been ruled about by what we know of the phenomenal realm through the investigations of science. All three are compatible with the probabilistic laws of nature discovered by physicists. Probability can, with equal facility, describe the behavior of minds or the mindless. It can describe the mindless roll of dice or the

conscious choices of a shopper.

Because all three theories are compatible with everything science has discovered about vision and visual experience, I've been careful to say that human vision "constructs" the objects and properties we experience, rather than that it "recovers" or "reconstructs" them. The neutral term "constructs" lets us discuss the phenomenal realm of vision without tacit claims about the relational realm. Saying that human vision recovers the 3D shapes of objects might suggest a version of physicalism in which there are 3D objects whose shapes are, in the normal case, dutifully recovered by human vision. This might be true or not. But we needn't decide the issue to profitably investigate your visual intelligence and how it constructs your visual experiences.

It might come as a surprise that all three theories are still compatible with all we know. Haven't the advances of physics by now settled the case in favor of physicalism? Not at all. The advances of physics have served to sharpen the issues and increase the debate, but not to settle it. And they've led to an interesting discovery: construction is at the heart of quantum physics. A central feature of quantum theory that has puzzled theorists for decades is the critical role of observation. When an atom or electron is not observed it has no definite position, no momentum, nor any other dynamical properties. Instead it's in a "superposition" of perhaps countless possible positions or momenta. Only when the atom or electron is observed does it have a definite value of position or momentum. For many theorists the puzzle is that this behavior of quantum objects seems so different from the behavior of everyday objects, such as volleyballs. After all, they point out, a volleyball, unlike an electron, does have a position, a momentum, a 3D shape, a color, and other such properties, whether or not the volleyball is observed. Why should observation be critical to electrons but not to volleyballs?

The puzzle is due, however, not to the strangeness of electrons but to a misconception about volleyballs. A volleyball no more has a position or momentum when it's not observed than does an electron. Only in the act of observation do you construct a phenomenal volleyball with a position, motion, color, and shape. Similarly, only in the act of observation is an electron constructed with a position, or momentum, or other dynamical properties. All phenomena are constructed by observation, whether quantum phenomena or volleyball phenomena.

If physics hasn't settled the nature of the relational realm, what about biological evolution? Don't the probabilistic processes of random mutation and natural selection, the main engines of evolutionary theory, settle the case for physicalism? After all, they can account nicely for the unity and continuity within the diversity of biological organisms, and they drive a synthesis that in principle spans from the humble amoeba to the phenomenal brain of man.

That may be, but physicalist, idealist, and dualist accounts are all viable. There is, to date, no valid argument whose premises are the probabilistic rules of evolution and whose conclusion is the nature of the relational realm.

This last statement might seem mistaken. After all, according to natural selection

those creatures whose perceptions are better adapted to the environment have a competitive advantage in the struggle for survival over those whose perceptions are less adapted. Over eons of time, creatures with less adapted perceptions have presumably disappeared, and those that remain have perceptions that are well adapted. We're among those that remain, and we see physical objects. So doesn't this settle the case for physicalism?

Not at all. Granting that our perceptions are well adapted, we must ask: well adapted in what sense? In the sense that perceptual experiences now resemble the relational realm? But this is more than natural selection delivers. Experiences need not resemble the relational realm to be well adapted, they need only be a useful guide for behavior. The icons on your computer screen are a useful guide for behavior toward your computer, but those icons don't resemble the circuits and software which ultimately determine how well adapted your behaviors are. Indeed the icons are a useful guide to behavior precisely because they don't resemble circuits and software. Circuits and software are extremely complex, and if your icons resembled them it would take you forever to get anything done on your computer. Your behavior would be less adapted, not more. Just try doing graphic design on your computer by setting registers and flipping switches, and you'll soon toss out your computer in favor of pen and paper. And that's why hackers put big effort into designing icon interfaces, and why consumers put big dollars into buying them: to provide a means of interacting with the computer which is useful precisely because it hides the complexity of the circuits and software they interact with.

If "well adapted" doesn't mean "resembles," then what does it mean? It means a systematic but arbitrary relation. Our perceptual experiences are well adapted to the relational realm because they provide a systematic but arbitrary guide to those aspects of the relational realm that are critical to our needs and our survival — just as the icon interface on your computer is well adapted because it provides a systematic but arbitrary guide to the computer's unseen circuits and software.

Something might still seem wrong here. Look, you say, when I see a snake slithering toward me in the grass, then I would be a fool not to think that there really is a snake, and I would be a fool not to get out of the way. Natural selection has seen to it that when I see snakes, there are snakes, and there is real danger.

Granted, when you see snakes there are snakes, and you must take them seriously. Similarly, when you see a trashcan icon on your computer screen, there really is a trashcan icon, and when you see a document icon representing that text file you've been editing for the last five hours, there really is a document icon. And you must take these icons seriously. If you drag that document icon into that trash-can icon then you'll lose your last five hours of work. That's a serious consequence. To say that experiences provide a systematic but arbitrary guide to the relational realm is not to deny that experiences are real and must be taken seriously. Snake experiences are real experiences and must be taken seriously. But they don't entail that anything in the relational realm resembles a snake, just as a trash can icon doesn't entail that circuits and software re-

semble a trash can.

Neither biology nor quantum theory dictates the nature of the relational realm. Nor does any other science. Each studies certain phenomena, and describes these by precise theories. In no case do the phenomena or the theories dictate the nature of the relational realm. We might hope that the theories of science will converge to a true theory of the relational realm. This is the hope of scientific realism. But it's a hope as yet unrealized, and a hope that cannot be proven true.

So this is a small sample of what happens when we peek behind the icons, when we ask what else there might be in addition to our perceptual constructions. We find a myriad of fascinating questions. We find that we've entered the province of philosophy and religion. Because the phenomenal and relational realms need not resemble each other, because their relationship is arbitrary and systematic, the tools of science can help us guess at the nature of the relational realm, but might never dictate a final verdict.