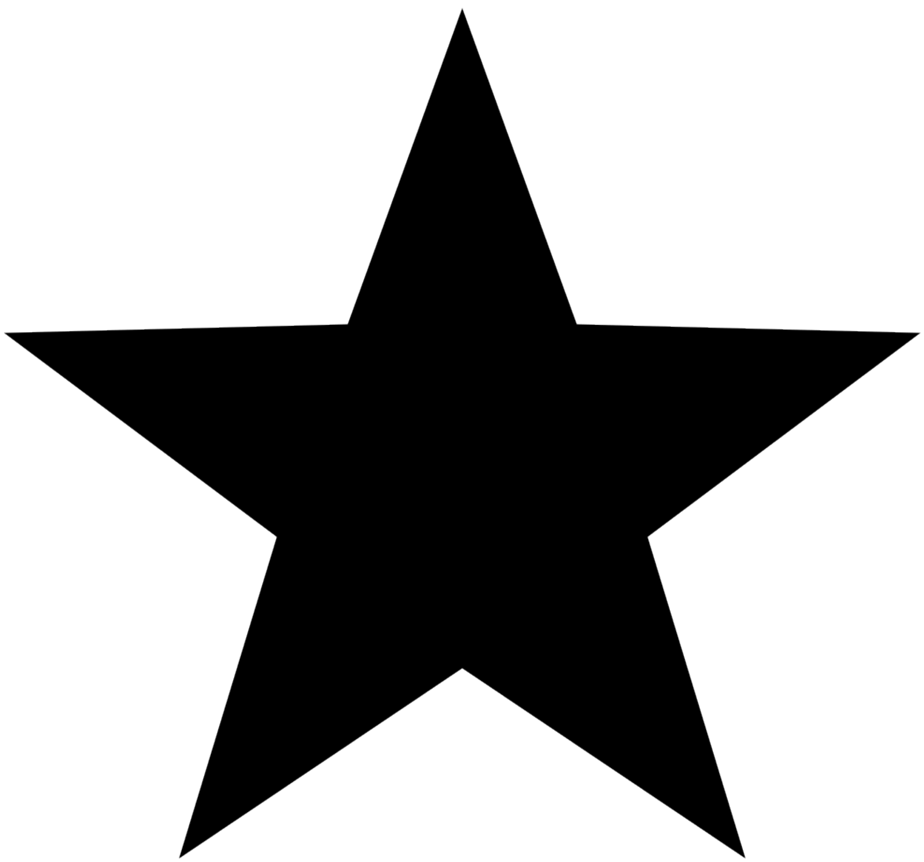
Compilation of Short Essays on Scienctific Philosophy Pt.1 [Mass Line]



Philosophy of Science & "Metaphysics"

Chopping Onions and Pragmatism

1.**Introduction**. A few days ago I went to participate in a feast my mother prepared in honor of the Easter Bunny. Actually I helped a little bit too by chopping up some onions to add into the scalloped potatoes. My mother doesn't like to chop onions because it brings tears to her eyes, and she suggested that in addition to going outside to the patio table to chop them up I also "put a piece of bread in my mouth" which she swears helps a lot. I refused to do so on the grounds that it made no theoretical sense to me! This refusal led to some considerable consternation in some quarters, and some considerable philosophical turmoil! Was I being irrational "not even to try" something that made no sense to me? Or is the "bread-in-the-mouth" technique itself irrational and an example of both pragmatism and self-delusion at work? Although this may not be the most important philosophical problem around, I propose in this essay to really try to think this thing through!

2.**The Scientific Explanation for "Onion Tears"**. First let's summarize the basic science involved here. The theory that I was working on is that when an onion is sliced a gas is generated from the crushed cells which travels through the air and when it makes contact with the water in a person's eyes forms sulfuric acid. Although the acid is dilute, it is still strong enough to cause the eyes to water to try to wash the irritant away. Hence the tears.

Afterwards, when I checked out the current status of this theory on the Internet, I found that it is still the accepted scientific explanation for the onion-tears phenomenon, but that many further details are now known—including one detail that was only discovered in 2002. No doubt further details will also come to light in the future, but most likely the basic theory will remain intact. Here is the more elaborated and up-to-date version:

When you slice the onion with a knife, even a very sharp one, you crush some of the cells. These cells contain amino acids and their derivatives which contain sulfur, including one called S-1-propenylcysteine-sulphoxide. These cells also contain two enzymes which are normally kept separate from the sulfur compounds. One of these enzymes is allinase, and the other—which was just discovered in 2002 by Japanese researchers—is called "lachrymatory-factor synthase". 1 When the two enzymes come in contact with sulfur-containing amino acid derivatives they produce sulfenic acids (amino acid sulfoxides), which in turn break down into the volatile compound propanthial S-oxide which in gaseous form makes its way to the eyes of the victim.". 2 At this point there are two sub-theories. Some believe that "the gas itself directly causes the nerve endings in your cornea to trigger a tearing response in your tear ducts". But the dominant theory seems to be that the propanthial S-oxide hydrolyses to propanol, sulfuric acid and hydrogen sulfide, and it is the irritation of the sulfuric acid which leads to the production of tears.3

Cooking, by the way, destroys the two essential enzymes, which is why cooked onions do not cause tears.

3.**Ideas on How to Prevent the Tears**. Now if this theory of what causes tears in the eyes of those cutting onions is correct (which science seems to pretty much confirm), then it clearly follows that the way to prevent the problem is to do things which keep the gas from getting from the onions to the eyes. Among the reasonable possibilities here are:

1. Wear goggles (preferably air-tight).
2. Cut the onions under water (so that the gas is dissolved there, and not in your eyes.)
3. Keep the onions wet as you cut them (even if they aren't actually under water).
4. Work outdoors, or in a well-ventilated room.
5. Work quickly (so that the gas doesn't have time to reach your eyes).
6. Use a sharp knife (so that fewer onion cells are crushed in the first place).
7. Keep your face far away from the onion you are cutting, and try not to raise your hands which are covered with onion juice up near your face.

All of these ideas seem to make sense, and many of them (including the first two) have been demonstrated to work.However, some of them are inconvenient (e.g., goggles) or perhaps even dangerous (using goggles or cutting under water may lead to cut fingers). But I've found that method A4, working outdoors or in a well-ventilated room, pretty much solves the problem for me. (This is one of the reasons I seek no further remedies, I suppose.)

There are also some other ideas that sound fairly plausible, such as:

1. Cut out the core of the onion first, where the root comes out. One source recommends cutting out a cone approximately one-third of the way to the center, and discarding it. The claim behind this idea is that this area of the onion supposedly produces much more of the gas which induces tears. (I don't know if this is true or not.)
2. Refrigerate the onion first. (Presumably to make the propanthial S-oxide gas less volatile.)
3. Put the onion in the freezer for a while before cutting it (for the same reason).
4. Whistle while slicing. (Perhaps this might blow the evil gas away from you. But done improperly it just might help circulate the gas up toward your face, too!)

One source which tested idea number B2 said that it doesn't work. I don't know if the still lower temperatures implied by idea B3 would work or not.

In any case, if you look around the Internet you will find lots of other ideas that don't seem nearly so sensible in light of the scientific theory of what causes onion tears. Here are just a few that I've come across.

1. Put a piece of bread in your mouth while you slice.
2. Chew gum while you slice.
3. Eat sugar cubes while you slice.
4. Put a slice of lemon in your mouth.
5. Retain water in your mouth.
6. Put the tip of a match in your mouth.
7. Breathe through your mouth.
8. Keep your mouth open.
9. Keep your mouth closed.
10. Submerge the onion in vinegar before you slice it.
11. Light a candle.
12. Use gloves. (This is based on the theory that the real problem is that the onion juices enter your body through your pores.)

Clearly not all of these can possibly be correct. (Ideas C8 and C9 are directly opposed, for example.) The ideas C1 through C8 could be based on the theory that the problem is that the gas enters the nose (rather than the eyes), and that therefore you should do something to keep the mouth open to promote breathing through the mouth. Many of these same ideas could also be interpreted as implying that one substance or another might absorb or neutralize the onion gas before the person breathes it. (As far as I know there is no evidence to support this.)

Is there any way that any of the ideas in group C might conceivably work? Sure, conceivably! Possibly lighting the candle, for example, could lead to air currents which could tend to pull the offending gas away from the onion and then up toward the ceiling along with the rising warm air. But is this actually very likely? I doubt it! (Candles cause very small air currents. A fan would do a much better job!)

It seems to me that many of the ideas can't actually work, however. Idea C12 has already been pretty much disproved by the demonstrated success of the goggle idea. (The person was still touching the onion with their bare hands, but had no problem with their eyes.) In the same way, most of the other ideas in group C seem quite dubious. If the goggle method works, then there can't really be much effect of the onion gas through a person's nose. And that means that all the ideas about putting things in your mouth, or breathing through your mouth rather than your nose, can't really matter very much. Yes, conceivably, that could have mattered; but the evidence suggests that it really doesn't. (The fact that something is "conceivable" is the cause of no end of false conclusions about what actually is the case! It is a major source of human error.)

The most intelligent way to proceed is to go by not what might conceivably work, but by what our theory tells us should work!

4.**Are Many People Wrong Then?** Many people swear by these various ideas in group C! Are they all just wrong? It seems that they are! One of the conclusive facts about human beings is that we are quite capable of becoming convinced of things which are just not true! Even those few who are cautious and skeptically inclined still do this at times, and those who are not trained to be cautious and skeptical are especially prone to it.

The fact is that people tend to jump to conclusions, and especially so about ideas they want to believe. Easy remedies for the problems they face are embraced with especial enthusiasm, regardless of the actual logic or evidence involved. This is why people pray to invisible gods up in the sky and actually believe that their prayers are answered. (It is possible, of course, that there may sometimes be a placebo effect involved here, though I doubt that helps much for prayers about winning the lottery!5) And it is why political demagogues can so easily pull the wool over people's eyes. We see this at the present time, for example, with the Bush Administration's imperialist war for control of Iraq and other oil producing regions under the phony excuse of a "war against the terrorists". A majority of the U.S. population accepted that nonsensical theory until it finally started to become clear to them that the war was only making the situation worse. (Most still do not understand that it is the previous predations of U.S. imperialism which are in fact the basic cause of this terrorist problem in the first place!)

It happens all the time that people talk themselves into believing that one or another off-the-wall medical remedy works when there is actually no good reason to believe it. The actor Steve McQueen, when he was dying from cancer, went to Mexico to seek out the quack remedy of laetrile. The fact that he died soon anyway hasn't kept some others from seeking out the same "remedy". When I was in high school I was embarrassed by my father's adoption of the "copper bracelet cure" for arthritis. (He quietly abandoned it after a while.) Others prefer the "magnetic bracelet cure". Could one of these ideas conceivably actually work? Yes, conceivably laetrile could have worked, or copper bracelets, or whatever. It's just that there is no good reason to think that such things work, and some actual good evidence to believe that they don't! And this is despite the fact that some people claim that it has helped them.

It comes down to this: What are you going to believe, unsupported anecdotal claims, or scientific evidence? And which of these two are you going to allow to guide your own actions and your own practice? Those of us who try to approach the world in a scientific way are very much aware that there are all kinds of ideas and theories out there, about everything under the sun, for which there is no good evidence. We consciously choose to ignore most of that! We even admit, that yes, once in a while, there will eventually prove to be some validity to a small number of these speculative notions, off-the-wall theories, old wives tales, and so forth. But for the most part our approach to the world is to ignore all that sort of stuff unless we are making some sort of systematic investigation of some specific question.

In the case of the "bread in the mouth cure" for "onion tears" I saw no reason to even try it. In the first place I was going outside to chop the onions, which from past experience I knew to be a largely effective preventative. In the second place

I could not see how the bread could possibly help! The testimonial from even my own mother was not enough to persuade me. And in fact, not a single tear did come to my eyes in this instance. (In some past cases I have been mildly affected after a while, even outdoors. Perhaps there was less wind on those occasions.)

But suppose I had acquiesced and put some bread in my mouth while also going outside to chop the onions. No doubt my mother and others would have in that case taken my failure to have any tears as evidence (if not outright “proof”) that the bread-in-mouth method works! Of course, it would not really have been any such evidence at all, since it turned out in this case that simply doing the chopping outside was sufficient to prevent the tears.

My mother too, when she slices onions, and even with the piece of bread in her mouth, goes outdoors to do so! If she really wants to give her bread theory something approaching a fair test, she should stay inside and use only the bread-in-mouth technique and see what happens! My understanding of the science involved leads me to firmly predict that in that case she will also come to the conclusion that the “bread-in-mouth” idea does not really work!

5.We All Work from Theories. The difference between the scientific approach on any question and non-scientific approaches is not that in the first case we work according to a theory and in the other cases we don’t. Actually, we almost always work according to some theory or other. The difference is that some theories are much better than others! Some theories are better elaborated, more considered, more coherent, and—most important of all—better tested!

In the present case, I was working according to a theory that at least roughly approximated the prevailing scientific understanding of the situation with regard to the cause of tears when slicing onions. This theory is either unknown to, or ignored in whole or in part by, those who favor the various ideas in group C, including the bread-in-the-mouth idea. But they do, nevertheless, have a crude theory of their own—such as that “somehow” putting a piece of bread in one’s mouth will prevent the tears. As I suggested earlier, there are some slightly more elaborate theories that may lie implicitly behind that idea—such as that much of the onion gas goes up the nose rather than directly to the eyes, and that the bread (or other things in the mouth) might absorb or neutralize the onion gas.

To use a rational and scientific approach in any task, no matter how mundane, we must first have some fairly accurate notion of the scientific laws and facts governing that situation. It may not matter very much whether we cry when cutting onions, but sometimes—as in national and international politics the proper approach becomes a matter of life and death. And partly for this reason it is not such a bad idea to get into the habit of approaching everything in a rational, scientific manner!

6.**Pragmatism**. So what is the relevance of pragmatism to all this? What is known as “pragmatism” is actually an amorphous group of related epistemological and methodological theories, and it would take us too far a field to fully disentangle the whole complex. However the first part of the entry on ‘pragmatism’ from one current philosophical dictionary will serve as an introduction:

pragmatism The philosophy of meaning and truth especially associated with *Peirce and James*. Pragmatism is given various formulations by both writers, but the core is the belief that the meaning of a doctrine is the same as the practical effects of adopting it. Peirce interpreted a theoretical sentence as a confused form of thought whose meaning is only that of a corresponding practical maxim (telling us what to do in some circumstances). In James the position issues in a theory of truth, notoriously allowing that beliefs, including for example belief in God, are true if the belief 'works satisfactorily in the widest sense of the word'. On James's view almost any belief might be respectable, and even true, provided it works (but working is not a simple matter for James). The apparently subjectivist consequences of this were wildly assailed by *Russell, Moore*, and others in the early years of the 20th century....6)

It should already be clear from this that pragmatism is a profoundly anti-theoretic doctrine. It says we shouldn't worry about what is actually or ultimately true, but only what "works". The fundamental trouble with this idea, however, is that we often find that what seems to be working for a while does not continue working. For a while you can smoke three packs of cigarettes and down a bottle of bourbon every day. But this is not a recipe for living a long, productive and happy life. To ensure that individual or social practice or activity will work it must be in accord with the real situation, and the only way to be sure that your activity always is in accord with the real situation is to fully understand the scientific laws governing that situation.

Pragmatists don't rely on any deep theoretical understanding of the world in order to guide their actions. They don't investigate and think carefully about the situations they face. They reject that approach, and instead rely on hunches, guesses, rules-of-thumb, prevailing superficial notions, ad hoc methods, spur of the moment improvisations, and so forth. If they do have some understanding of the situation they face, they don't try to extend or deepen that understanding.

Thus pragmatism is not only profoundly anti-theoretic, it is also profoundly anti-scientific. (And this is true despite the claims of being pro-science on the part of many of its adherents, such as C. S. Peirce, William James, John Dewey and more recent philosophers such as Richard Rorty.)

Pragmatism as a philosophy was invented in America, and has always been much more popular here than anywhere else in the world. It has in fact become the dominant philosophy in this country, at least for the ruling class. According to James, " 'The true', to put it very briefly, is only the expedient in the way of our thinking, just as 'the right' is only the expedient in the way of our behaving."7) There is something amenable to an imperialist and world-dominating America to think that truth and morality are merely that which serves our own short-term and selfish interests.

But ordinary people too, and not just in America, tend to gravitate toward pragmatism in their practice (if not in their proclaimed philosophy).

When we approach an ordinary problem in daily life, such as how to slice an onion without having it bring tears to our eyes, we can do this in a haphazard, off the cuff, pragmatic sort of way, or we can do this in a more theory-influenced and scientific way. The way just about everybody does this sort of thing is in the half-assed, pragmatic sort of way. We may have heard somewhere that some technique or other (such as a piece of bread or a match stick in the mouth, or lighting a candle) may prevent the tears, and so without thinking things out any further (let alone doing any real investigation) we might well try such an idea. If we don't have any tears, then we say that the method we tried "works". Since we didn't carefully think about the whole situation, with a theory of what causes the tears in mind, it does not occur to us that just perhaps we didn't have any tears this time for some other reason (such as that the ventilation was good). Our "confirmation" of our off-the-cuff idea might very well be as phony as the idea itself!

Alternately, we might try to learn and think about what the basic problem really is (in this case that some unpleasant gas is coming from the cut onion up to our eyes) and just how we might go about preventing that. Various theories might come to mind. It might occur to us that if we refrigerate the onion first that will make the offending substance evaporate less easily. Apparently the substance is so volatile that this makes no real difference, however. So we might try goggles, or perhaps just opening the window and starting a fan. With a correct theory of what is causing the problem in the first place, it won't be long until we find some reasonable solution to it. This is the theory-guided, scientific way to proceed. And it is the way that works best for solving not only little things like the "onion tears" problem, but for all problems of any size and degree of seriousness.

7.**But Can't False Theories Also Mislead Us?** Yes, they can! Suppose the currently dominant scientific theory about what causes onion tears is false. Then my working according to that false theory could have turned out to be a mistake. If some other theory of this situation is actually correct, such as that the gas mostly affects us by going up our noses (and then indirectly affecting our eyes), then perhaps the bread-in-the-mouth idea would actually work. It is certainly not inconceivable that the bread trick might somehow work!

There is no absolute guarantee that if we work according to currently accepted scientific theory we will get the results we expect and seek. But the point is that this is nevertheless normally the best and wisest way to proceed.

My wife, Sara, pointed out that refusing to try things, and refusing to check out herbal lore, "old wives tales", and such, is not actually very smart. Some pharmaceutical companies, for example, have learned that one good technique to discover new drugs is to investigate the medical and herbal lore of native peoples (in the Amazon, New Guinea, etc.). It has happened on a number of occasions that the leaves or bark of some plant actually does contain substances which can help some medical problem. Although the native peoples might not know why some treatment works, they may still have discovered by trial and error that it does work. And science can learn from this traditional knowledge. One of the earliest examples took place hundreds of years ago when western medicine learned about quinine as a treatment for malaria from the Amazonian natives.8

I agree that it is appropriate and wise to try many different things—including things which are not in accord with your existing theory—when you are setting out systematically to discover the real and complete truth about something. That is, when engaged in any serious scientific investigation your existing theory should serve as your principal, but not exclusive, guide.

But when it came to chopping up some onions last Sunday I was by no means engaged in such a systematic investigation. I merely wanted to proceed with the chore in a way that my existing theory told me would be effective in preventing most or all of the tears problem. Thus I went outside to do the chopping. No additional techniques, especially those inconsistent with my operating theory of the situation, were needed or even appropriate in that context. Consequently I still maintain that I was right "not even to try" the bread-in-the-mouth technique. And if I had tried it (in addition to going outside) it would have demonstrated nothing.

I am open to rebuttals!

Oh, and by the way: That scalloped potato dish with all those onions in it was good! Damned good! —Scott (4/13/07)

The Impossibility of Infinitely Small Particles

This is an essay I wrote in 1989 for folks in a physics discussion group I was part of for a while, led by Steve Bryson as an adjunct to a short course on particle physics he was teaching at the California Academy of Sciences.

At the first session of our physics discussion group, Steve Bryson asked each of us what we thought of the idea of "point-like" particles, and also more specifically, point-like particles which have mass. I claimed that particles must have a volume, and that in particular it must be absolutely impossible for there to be a particle with mass that is a mere mathematical point (or that is "infinitely small").

Why must it be impossible? Because anything that has mass (at least) is part of the world, i.e., it is a chunk, or piece of the world. A mathematical point is not part of anything physical. The only things that a mathematical point can possibly be part of are other mathematical "objects", such as collections of points, lines, spaces (in the mathematical, not physical sense), etc.

Mathematical "objects" are not physical things. The number 2, for example, is not a physical thing in the world. It is a concept, or intellectual abstraction, derived from considering things (either "real" things, or other abstractions) in pairs.

(In Principia Mathematica, Bertrand Russell and Alfred North Whitehead define natural numbers in this way (partially any way). But this is not my argument.

You can no doubt "define" numbers in numerous different ways in formal logico-mathematical systems. I am only claiming that our everyday mathematical concepts such as '2', 'point', 'line', etc., are abstractions from things in the real world (such as pairs, tiny objects, threads or objects-in-a-row, etc.). That is, this is historically how they must have been derived; this is where such concepts were abstracted from.) Like the number 2, mathematical points, lines, etc., are also not part of the physical world. They are also abstractions from things in the world, very small things in the case of points; threads, or pencil lines, or things-in-a-row, in the case of lines.

Thus my position is that nothing that is part of the world can possibly be a mathematical object like a point. To claim such a thing is to confuse two entirely separate categories of things, things as different as the moon and ideas, or of canvas and paint on the one hand, and abstract patterns on the other.

However, I am not denying that we can (and do) treat physical things in the world as if they were mathematical points. If we did not have reason to do this, the concept of a mathematical point would never have been created in the first place. In particular, it has been a commonplace feature of physics, since at least Newton, to construct physical theories in which physical objects were treated as mathematical points within the theory.

Thus in Newton's theory of gravity, all the mass of a physical object like the earth is generally considered to be concentrated at a single point at its center (actually at its "center of gravity"). Newton proved that it is acceptable to do this for cases in which the earth's gravitational attraction is being considered in relation to another object outside of the earth; that mathematically it is equivalent to the real physical situation where the mass of the earth is actually spread out within the whole volume of the earth. It is of course the integral calculus (invented by Newton and Leibniz) which allows you to make such calculations relatively easily.

In the case of the earth, no one is apt to forget that while the mathematical theory (Newton's equation of gravitation) treats the earth as if it were a single point, actually it is not a single point. But when it comes to particles at the atomic scale or smaller, we do not have this constant reminder that reality is more complex than our mathematical models of it. The tendency is always to assume that there is nothing more to say about these particles—nothing more that can be said—except what is incorporated into the mathematics of our current theories. Thus if the theories treat a particle as if it were point-like, the tendency is to jump to the invalid conclusion that it actually is a point.

The dispute between those (like me) who deny that any part of the world can actually be a mathematical point, and those (like many contemporary physicists) who claim otherwise, is an example of the age-old philosophical dispute between materialism and idealism. Materialists hold that the world actually exists independently of mind and of our ideas and abstractions of it. Idealists think that in some sense ideas or concepts are primary, and that matter (if it really exists at all) is somehow an outgrowth of these ideas.

Mathematicians have always tended to lean towards idealism. "All is number," said Pythagoras. Mathematicians have a difficult time resisting the view that the mathematical objects that they work with daily must have an existence every bit as "real" as that of tables and chairs. Or as the great English mathematician, G. H. Hardy, put it:

For me, and I suppose for most mathematicians, there is another reality [besides "physical reality" —JSH], which I will call "mathematical reality". . . . I believe that mathematical reality lies outside us, that our function is to discover or observe it.1

But while it is true that ideas "exist", and that patterns and abstractions can be created or made—or "discovered", if you will—the existence of these "objects" is not the same kind of existence as matter (and energy). Instead the existence of ideas, patterns, abstractions, etc., derives from, and depends upon the existence of matter.

Physics has gotten steadily more mathematical, especially over the past 100 years. To a certain extent this has had the result of turning physicists into mathematicians, and it has also fostered the growth of mathematical idealism among physicists. (I will resist the temptation to also tie the tendencies towards idealism to the continued existence of capitalism, since I know that will offend some people!) Wolfgang Pauli, for example, was a fine mathematician himself, and remarked that "The steady progress of physics requires for its theoretical formulations a mathematics that gets continuously more advanced".2 And yet Pauli also thought there might be something to astrology, and other screwball metaphysical theories.3 Of the biggest names in physics this past century, Einstein stands almost alone in his staunch materialist tendencies. (But even if Einstein was almost alone, I am quite happy to side with him!)

Since Ernest Rutherford's experiments around 1910 we have known that atoms have physical volumes consisting mostly of the "electron cloud" (the region where the electrons in the atom may be found), and a very small nucleus where most of the atom's mass is concentrated. But though the diameter of the nucleus is only about 1/100,000 of that of the atom as a whole, it still takes up a definite volume of space. The nucleus is composed of protons and neutrons, and it has been determined that each of these "nucleons" itself takes up a small but definite volume, and is comprised of 3 quarks within that volume.4

But isn't there actual evidence that some particles are "point-like"? As Steve Bryson remarked, it is more correct to say that in the case of some particles (electron, muon, neutrinos, quarks, etc.), the only thing known about their size is that it must be below certain values. What evidence there is actually suggests these particles, though indeed very small even by the standard of the diameter of the proton, still must have some size.

Consider for example the scattering experiments which showed that there is a structure to each nucleon, and provided experimental evidence for the quark model. In these experiments beams of highly energetic electrons, muons and neutrinos have been used to bombard protons, and have shown that protons have small internal regions of higher than average mass and charge (which we assume to be the quarks). But the thing to notice here is that these experiments are showing a definite probability that these particles (which many consider to be "points") will hit and bounce off of other particles (quarks—which these same people also consider to be "points"). If all these particles were actually "points" the probability of their hitting would be zero (since a point is mathematically zero percent of any cross-sectional area).

(Of course, one can quibble a bit here. It is true that the trajectories of the "bullets" and the positions of the target nucleons will be changed somewhat due to electromagnetic (or weak) forces between them, and one could argue that this allows "point" particles to collide. But if this were true the probabilities for collisions would drop off significantly as the bullet energies were increased, and I'll bet you that this does not happen! (At least once a certain threshhold is reached.) I don't know if experiments have been done to test this, however.)

That these scattering experiments do show a certain probability of collision between the "bullets" and the target quarks is in fact all that is necessary to estimate the size of the quark. (Remember that it was this same type of experiment that allowed Rutherford to determine the size of the nucleus of the atom.)

The new HERA (Hadron-Electron Ring Accelerator) scheduled for completion at the DESY lab in Hamburg in 1990 is supposed to have enough power to "probe the structure of the proton to a separation of 10-17 centimetres and check whether quarks look pointlike at this close distance."5 So the dogma of quarks being mere points may soon fall. (Of course the option of jumping to the conclusion that the particles at the next level are "mere points" will still be open for die-hard idealists!)

Most of the discussion I have seen about the these "point-like" particles, however, has been focused on the electron. One recent book described the situation for the electron as follows:

In the 1930s, physicists devoted much attention to the question of the electron dimensions and tried to develop a theoretical formula for its diameter. They arrived at the formula r = e2/mc2

where e and m are the charge and mass of the electron and c the speed of light. This gives a value of 3 X 10-13 centimetres for the radius. In some phenomena—such as the scattering of light by electrons in the atom—the observations are consistent with this radius, but according to more recent experimental data and the theoretical framework provided by QED, the electron is practically a point particle whose mass and charge are concentrated in a region smaller than 10-16 centimetres.6 It is clear that by "practically a point particle", all that is really meant here is that the diameter is very small with respect to the volumes under discussion. This quotation also brings out the difficulties—and to some extent the arbitrariness—of the concept of a diameter of a particle.

But I don't care how small the diameter is, or how arbitrary the electron's boundaries are; I only wish to claim that the electron is not infinitely small, is not actually a "point".

The diameter of the earth is also somewhat arbitrary. Should one include the atmosphere? How high up? In point of fact the diameter of any physical object—no matter how big or how small—is ultimately somewhat arbitrary. The reason is the same as before: a "diameter" is only a mathematical abstraction. For some purposes we may choose to consider the diameter of the earth sans atmosphere, and by averaging out the heights of mountains and valleys. For other purposes, we may wish to consider the diameter of the earth to be the average extent of the magnetosphere. The fact that we may now choose to treat the earth as having one diameter, and later choose to treat it as having another diameter, or even to treat it as having no diameter (as a point)—none of these theoretical conveniences shows that the earth is actually a point, or that it does not take up some volume of space.

The same goes for the electron.

"So then, Scott, you think that the electron is a solid little marble." Not at all. It is invalid logic to assume that the only possibilities are mathematical points or solid marbles, as Abraham Pais does:

. . . the old quantum theory eased the transition toward an electron without spacial extension.

All the same the classical electron radius remained a concept hovering just barely off-stage, even though special relativity abhors finite-size rigid bodies. To face the alternative, a point electron, was abhorrent for other reasons: a zero radius for the electron means an infinite self-energy [the electrostatic energy of the electron at rest, which is defined as e squared over radius r, and thus tends to infinity as r goes to 0. —JSH]. . . So, I would think, one rather suffered a particle of finite size than a particle with infinite mass.7

Pais says later that this dilemma has been resolved. Since ". . . it has definitely been established that the electron's self-energy is not purely electromagnetic in origin"8 the difficulty of the electron's self-energy going to infinity as the radius goes to zero supposedly no longer presents itself. (I don't understand this specific claim well enough to take a position on it one way or the other. But isn't it suspicious that the "resolution" of this problem is left so vague by Pais?) ". . . the classical answer (for the value of the total self-energy of the electron —JSH) returns if one makes the absurd assumption of an electron radius large compared with the Compton wavelength. Whatever the future may hold, the tiny marble with energy e2/r is gone forever."9

But I am suggesting that there was never any real dilemma in the first place (perhaps only a trilemma!); there is at least one other possibility besides hard marbles and mathematical points. "Such as??" Such as the possibility that the electron itself has a structure, that it is made up of smaller particles, perhaps. There is no reason to assume that if it has a radius it must be some "solid" or homogenous substance throughout its volume.

"And what of those 'particles' that you suppose electrons might be made up of? Are they point particles, or do they have volumes too?" Whether the hypothesized structural components are the sorts of things which should be considered to be particles at all is not something which I can say with any assurance (though I suspect the answer will turn out to be that they are). In any case, no structural component can be a mathematical point (or other mathematical "object").

"So! Your position leads to an infinite regress of particles, or structures within structures. . . ." This is what Steve Bryson was getting at, I think, when he challenged me in our first discussion session to consider the implications of always dodging solid marbles and mathematical points by hypothesizing further internal structures.

One possibility is that there is an infinite regress of internal structures. I find this possibility unpalatable, but infinitely preferable to the idealist alternative of saying the world is ultimately made up of abstract mathematical ideas, like "points"—a view which I can make no sense of whatsoever. If no other possiblities prove out, then I will fall back on this hypothesis of an infinite regress of internal structures.

But I think there are other alternatives to mathematical points. Perhaps we will find out that at some level matter really does consist of homogenous chunks ("little marbles", or perhaps "little strings"—but not one dimensional!) and that the old bug-a-boos, such as infinitely fast shock waves, either do not apply at this level, for some reason, or do not cause any insurmountable difficulties. (Perhaps at the quantum, or "sub-quantum", level there is no way to even initiate shock waves within this homogenous matter.) It would be ironic if old Democritus proved to be correct after all!

Or perhaps there are other possibilities, options other than mathematical points, "little marbles", or infinite complexity. I admit that the imagination is stressed at trying to discover such possibilities, but this is probably due mostly to our attempts to find everyday analogies for phenomena in the micro-world.

The one thing that is certain, as far as I am concerned, is this: except as a convenience within our theories that describe nature only partially and approximately, there is really no such thing as an infinitely small particle.

Pointless Poems

Pointless Poem #1

Some physicists imagine point particles;
Whose diameters are infinitely small.
I'd like to see in their articles
How that differs from not being at all!

Pointless Poem #2

To physicists sick with idealism,
"Point-like" particles seem like true realism.
But if they're infinitely small,
Can they be there at all?
To me these strange views are surrealism.

—Scott H. 2/21/89 (with revisions on 3/5/89)