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The cover design for the FALL/WINTER 2007 issue of *BRIDGES* was created by **Mr. Ty Bachus**.

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# Quantum Physics and Welfare Policy?

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Jack C. Straton

*Welfare policy is examined through the paradoxical logic of Nagarjuna's tetralemma, providing a lens through which wave-particle duality in quantum mechanics is then viewed. Through this process students are challenged to radically expand their critical-thinking horizons beyond conventional dualistic bounds. They learn not only this key property of quantum reality, but have to come to grips with the nature of knowledge itself, and the degree to which they censor their own awarenesses.*

**Keywords** Wave-particle Duality; Welfare; Nagarjuna; Tetralemma; Catuskoti Logic; Tetralemma

## Introduction

A number of books (Capra, 1975, Zukav, 1980) and films (Capra & Stars, 1991) have been produced in the last few decades that seek to explain mystical reality by drawing on quantum physics to apply a gloss of scientific authority to some of the mystical belief systems of the East and suggest how the latter fit into everyday life. I decided to experiment with reversing the flow of persuasion, using a hot topic from everyday life within the paradoxical logic of Buddhism to help my students grasp the most difficult essence of quantum reality, wave-particle duality.

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The context for the lesson is a team-taught, multidisciplinary, year-long course that serves as the entry point to the revolutionary general education reform program at Portland State University (Rennie-Hill, Leslie & Toth, Michael A. 1999). The over-arching goal of the *Values in Conflict* course is to help students become conscious participants in their own value systems and to help them examine the conflicts that occur in society when perspectives collide and individual rights conflict with social and community responsibility. We focus in turn on Awareness and Responsibility, Scientific Ways of Knowing, and The Art of Politics and The Politics of Art. Linda George, Lorraine Mercer, Veronica Dujon, Mark Trowbridge, and I each have primary responsibility for teaching one of five parallel classes of about 40 students and frequently are guest instructors in each other's classes when the topic focuses on our fields of specialization: chemistry, literature, sociology, art history, and physics and diversity training, respectively.

However interesting I find quantum scattering theory (my area of specialization) to be, students in a required course such as this are not prepared to set aside their generally-held math and science phobias to explore quantum reality (or even topics in general physics) without some kind of bridge from the humanities that they are more comfortable with. The same problem holds true for the other professors on my teaching team. Thus, my goals in teaching quantum theory have little to do with content transference and much to do with having students learn two complimentary boundaries on knowledge: that there are fundamental limits on what anyone can know (Heisenberg's Uncertainty Principle) and that we often shy away from exploring more than one of the knowable perspectives (wave-particle duality).

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### **Knowledge and Suppression**

Our classes begin the focus on science by discussing what science is and is not and examine how scientists make truth claims. Linda George has our students engage in “Fermi-type” experiments, such as choosing “tools” from a grab-bag of common household items to estimate the volume of air one breathes in a day. As we have noted in more detail elsewhere (George & Straton, 1999), students generally have oppositional views on the nature of scientific knowledge. On one side are students who sense that knowledge that has been derived scientifically is “factual” and is closer to the Truth than other ways of knowing. Alternatively, when we expose our students to the notion that knowledge is mediated by one’s perspective (Tompkins, 1999, pp. 272-692), this is often absolutized to mean that there is no “real” knowledge since “everything is biased.”

Appropriate to a paper on wave-particle duality is the observation that some students simultaneously, serially, or oscillatorily belong to both camps of thought, generally either with little self-awareness of that fact or with an overt effort at censoring their awareness. Paradoxically, we dive into the very foreign world of the quantum to help them begin to perceive the dual nature of their own persons and the understanding that blocking out things that they can know because they don’t fit their current belief system may not be in their best interest. Specifically, we dissect the subject of “knowability” by exploring wave-particle duality in the quantum world.

### The Wave Nature of Light

I teach the basics of wave-superposition (see **Figure 1**) by having a student on one end of a long spring maintain a standing wave on the spring and then I move my hand at twice the frequency to superpose a wave on top of the fundamental one whose wavelength is half as long, as in **Figure 2**.

Next I use a double source of waves in a ripple tank (affixed with a strobe light at a matched frequency) to show that wave superposition—positive and negative interference—in two dimensions produces the quilted pattern (**Figure 3**) that is familiar from splashing in the bathtub.<sup>1</sup> I ask them to characterize the wave height of the interference pattern if one were to take a one-dimensional slice through the water (**Figure 4**). They describe it as alternating troughs and crests along the slice.

When I next send a laser beam through a pair of slits, students see it produce a light-dark-light-dark pattern similar to the interference in the ripple tank, and confidently state that this shows that “light is *made up of waves*.” By widening and narrowing the slits I show them that the interference disappears if the distance between the slits is much greater than the wavelength of the light (**Figure 5**).

I then turn to Einstein’s explanation of the photoelectric effect, but recast in the analogy of a Sun bather: Why would a light-skinned person get a sunburn at noon but not as the sun sets? (They observe that the path of the sunlight through the long stretch of atmosphere from the horizon filters out the UV (ultraviolet) light that causes burning.) Actually, rather than being absorbed, the wavelengths of UV through blue light are short enough to be scattered away from the light’s path by dust. This light is

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continually rescattered so that we see it coming down from above away from the sun. This is why the sky away from the sun is blue. Students notice that the more dust or smoke there is in the air, the more scattering takes place, leaving only the reddish wavelengths to hit the sunbather from the direction of the sun. Likewise a longer path through the air (at 6 pm vs. noon) means less UV will reach the sunbather.

But this brings up the question of why red light does not burn the skin. This query is dramatized by exposing to sunlight (or the blue strobe used in the ripple tank demonstration) a sheet of blue-sensitive photographic paper that requires no developer to darken.<sup>2</sup> Students see it darken while another sheet placed in the path of the red laser remains white. I ask if there is any student who would take a “double-dog dare” to put their eye in the laser light beam for the same amount of time. They understand that it is a very high amplitude wave, so I get no takers. But they still do not know why the red laser light does not darken the paper but will burn out their vision.

The lesson in light waves—that even a small amount of UV light will burn skin or darken photographic paper whereas an immense amount of red light will not—is brought to critical focus by recasting it in terms of water waves. The results of these experiments are like saying that a person standing on the shoreline will get knocked down by a tiny (1 inch) amplitude wave having a very short wavelength (UV), but will not be affected by an enormously high (100 foot) wave with a long wave-length (red). Their personal experience with water waves (longer ocean waves vs. shorter waves often found at a lakeside) contradicts this assertion. The only way out of this absurdity is to abandon the idea that light is a wave and state that “light that it is *made up of particles*, that it is *quantized*.”

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At this point my students believe that I have lied to them at least once, and probably twice. Their frustration is palpable in the air. I further that frustration with “knowing the Truth” by showing interference in images of electron diffraction by crystals (compare **Figure 6** to **Figure 5**), demonstrating that “particles also appear to *be* waves.”

After a pause I give them some release from their cognitive dissonance, a release that comes at a cost: they get it only if they embrace a paradoxical reality. I show them a photographic image made up of just 3000 particles of light, or *photons*, striking seemingly at random (**Figure 7a**). But with 12,000 photons, an image begins to appear. One can see where photons seem to cluster about the nose while the eye socket remains free of photons. At 28,000,000 photons, we see a smooth image. The answer to our quandary that satisfies emotionally is to say that “light travels like a wave and interacts with matter like a particle.” But what does that really mean? How is a student to get a feel for something that runs roughshod over intuition? Perhaps learning a new analytical tool would help.

### **Expanding the Possibilities of Logic**

This business of light having both wave- and particle-like properties and matter having both particle- and wave-like properties poses a particular challenge for “Western Logic.” Our philosophical systems, and hence our scientific systems, are founded on dualism; that a certain thing is either “A” or it is “not A.” It is true that some westerners such as Fitzgerald (1936), pay lip-service to the idea that “the test of a first-rate intelligence is the ability to hold two opposed ideas in the mind at the same time, and still retain the ability to function,” but offer no formal recommendations on how one is to actually learn to do this.

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Since one of the goals of PSU's Freshman Inquiry is critical thinking and another is multicultural awareness, this is an excellent opportunity to see if there is any merit in a logical process from another culture used as a means for students to get a feeling for quantum mechanics. Specifically I turn to the Four-Fold Proposition<sup>3</sup> of Nagarjuna (c. 150-250 B.C.E.), the Indian philosopher who brought Buddhism to completion (Sekeida, 1977, p. 183).

To visualize Nagarjuna's logical system one may represent a given reality by a four-sided pillow (Reps, 1967, p. 17), as in **Figure 8**. One asserts the validity of some perspective on a given idea, actual entity, or experience, that I will call "A," and then states every argument one has to affirm that that perspective is true. Next one moves to the second side of the pillow and states every argument one can find to show that the first assertion is not true, a perspective I will call "*Not-A*." That step alone is tough for westerners, who like to see in black and white.

Next one moves to the third side of the pillow and states every argument one has to show that the assertion is **both true and not true**, a perspective I will call "**Both A and Not-A**." That step is explicitly disallowed by western logicians.<sup>4</sup> Next one moves to the fourth side of the pillow and states every argument one has to show that the assertion is **neither true nor not true**, a perspective I will call "**Neither A nor Not-A**," a way of perceiving more natural to one<sup>5</sup> Eastern belief system founded on the Totality of Emptiness<sup>6,7</sup> than a Western one founded on eternal Ideas<sup>8</sup> or Forms.<sup>9</sup> Wrapping our minds around this step seems to be the toughest. Finally, one

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affirms that there is just one reality (represented by the center of the pillow) from which each of these perspectives arises.<sup>10</sup>

### For the Affirmative

To get students personally involved in the process, I use the ongoing social controversy over welfare as the grist for this logical mill. Let *A* represent the point of view that “we as a society should drastically cut welfare,” as was done August 1, 1996, ending 6 decades of federal assistance (Bassuk, Browne, & Bruckner, 1996, p. 62)<sup>11</sup> to poor parents and their children. I ask those students who substantially agree with the proposition, that we as a society should [have] drastically cut welfare, to physically move to one side of the room and those who substantially oppose the proposition to move to the other side and allow no fence-sitters. (Where would the reader place himself or herself?)

To get students in a new frame of mind I ask the latter group, those who oppose the proposition, to come up with every argument they have heard or can imagine that can support it, whether it has any basis in fact or not. At first they think that they cannot do this, but eventually come up with a comprehensive list. A large subset of the following points goes up on the board in one wedge, as in **Figure 8**:

Welfare causes high taxes, breeds criminal elements, is a control measure (for women), undermines human dignity, increases poverty because people don't try for jobs, wastes money, encourages women to have more kids, is intergenerational (self-perpetuating), undermines family values, causes graft, and is abused. People don't want to be on welfare. They hate dealing with a bureaucracy. *Those people* (e.g., Liberals or Democrats) support it. We need to balance the budget.

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We need to teach individualism. The cream rises to the top. There's a chain of dependency. If *they* died, it would decrease the surplus population. They're lazy bums. Welfare Queens! [These two-words capture a constellation of meanings that proponents seldom need to actually spell out]. Immigrants! Parasites!

One can also add some articles and editorials from the popular press: By 1996, "[e]ven single working mothers understandably wondered why they were paying taxes for other single mothers to stay at home."<sup>12</sup>

I eventually allow the actual supporters of *A* to speak and ask them whether the opponents of *A*, who were quoting supporters' arguments, had left anything out and, if so, allow them to add to the list.

### **For the Negative**

We then move to *Not-A*. I ask the supporters of *A*, who want to cut welfare, to do their best to pose all of the arguments in opposition to the proposition to cut welfare. They pose all of the arguments that "we as a society should not drastically cut welfare," whether they have any basis in fact or not:

People with disabilities need it. Subsistence is a basic human right (in the middle ages, serfs had to obey their Lord, but he had an obligation to protect and feed the serfs). Kids would suffer and they didn't choose to be born.<sup>13</sup> Some people need it. Cutting welfare would exacerbate the division between rich and poor. Welfare provides a platform for growth, and job training. "There, but by the grace of God, go I." Poverty breeds crime. People don't want to be on welfare. It is poverty

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that encourages poor people to have more kids<sup>14</sup> to support them when they're old. We help the poor in other countries. It gives kids a future. Compassion teaches better parenting. It is evil to let people starve.<sup>15</sup> Women escaping domestic violence may need it. It's an investment in the future. It helps prevent abortion. Don't give bureaucrats more power.<sup>16</sup> "From everyone who has been given much, much will be demanded; and from the one who has been entrusted with much, much more will be asked."<sup>17</sup>

For some reason, participants who substantially agree with the proposition to cut welfare have a harder time coming up with the arguments in opposition to those cuts than the reverse. Perhaps this is a consequence of the over-abundance in the number of right-leaning talk radio hosts and in the vehemence of this ideologically-skewed coterie of opinion-makers. I find I usually have to help more to get a comprehensive list, and also have to add more articles and editorials from the popular press:

Welfare is temporary, with the median lifetime stay for one study<sup>18</sup> "of about two years for homeless women and 3.5 for the housed. About a third of the women had used ASFDC for a total of five years or more." "Two-thirds of the mothers in [one study] had not grown up in families that were receiving welfare."<sup>19</sup> As for the idea that welfare undermines the work ethic, many "low-income mothers supplemented their AFDC grants by working at low-paying jobs with no benefits."<sup>20</sup> Teen mothers are not the predominant group. Unmarried women under age 18 make up "only 7.6 percent of all mothers who received welfare in 1993. . . . The median age of [this] sample was 27.4 years."<sup>21</sup>

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“Nationally, 57 percent of poor women have court-awarded child support. . . . The new law cuts welfare benefits to a mother by at least 25 percent if she does not identify the father . . . [but] many women will continue to refuse for fear of retaliation” by their abuser.<sup>22</sup> “A shocking 91.6 percent of the homeless and 81.8 percent of the housed mothers reported physical or sexual assaults at some point in their lives.”<sup>23</sup>

As for workfare, “76 of the 100 biggest companies have no plans to hire anyone off welfare—unless a welfare recipient applies and gets a job the old-fashioned way. . . .”<sup>24</sup>

I eventually allow the opponents of *A* to speak and ask whether the supporters of *A*, who were quoting opponents’ arguments, left anything out and, if so, allow them to add to the list.

We pause for a minute at this point to let the students look at what they have done. I ask whether they ever hear Rush Limbaugh talking about *A* and *Not-A*? Teddy Kennedy? They all have stepped outside of the blinders our society tries to lay on them. Even if they don’t exactly believe the arguments they are quoting, many have a thoughtful look to their eye that indicates that they award some bits of truth to the arguments on the “other side.”

### **For the What?**

We then move to the third side of the pillow, “**Both *A* and *Not-A*,**” by asking the students to mix together. They are then asked do their best to pose all of the arguments in support of the statement that “we as a society **both should and should not** drastically cut welfare.” They inevitably begin to talk about welfare reform, and

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I ask them to save solutions for later, that we are looking for perspectives now.

They initially seem stuck, having had no training in paradoxical thinking, so I point out that we just listed a bunch of good arguments both in support and in opposition to the proposition, and a number of concerns actually appear on both sides, and ask for them to extract them:

Both show interest in human potential, talk of increase in the birth rate, quality of community, crime concerns. Some people on both sides of the issue hate bureaucracy and don't want to give bureaucrats more power.

This latter phrase stands as the model for phraseology we seek for this side of the pillow. I prime the pump with another example:

Do you think that the rich more often are in favor of cutting welfare or not? (They want to cut it.) But if it is cut, what will the starving people do? (Turn to crime or revolution.) Thus, the wealthy should support assistance to the poor because without it there will be revolution and the masses will steal their money. In other words, the rich should both want to cut welfare and not want to cut welfare.

(Some may counter that the poor steal mostly from the poor, but the rich nevertheless spend a lot of money to hire more cops or buy a better security system. And these are the folks who want to cut welfare because it costs too much. This also affects the middle class, whose theft insurance rates go up as this process unfolds.)

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Other perspectives that students have come up with to support the proposition that “we as a society **both should and should not** drastically cut welfare” include:

Welfare [barely] upholds a quality of life that is America’s image in the world. Those who want to promote *laissez faire* capitalism as the road to the land of plenty had better want to keep images of starving children off the news.

Liberals want a system that provides subsistence but in actuality the restrictions that come with welfare and the low level of support are in many ways debilitating.

“We slash welfare as a means to separate the rich from the poor, and we keep welfare as a means to separate the rich from the poor.”<sup>25</sup>

Why not have a system wherein those who hate welfare can direct their money away from welfare recipients and I can direct my money away from the military? Although this sounds like welfare reform, it is more than that. Dispensing with a monolithic tax system raises an interesting paradox: it would be embraced by survivalists (e.g., Posse Comitatus), generally mature rural (“White”) adults whom one would normally place on the far right politically, and by anarchists, generally counterculture city (“White”) youth in their twenties whom one would normally place on the far left politically. Both are distrustful of government, prone to conspiracy theories, and enamored of disruptive tactics.

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Although some of these arguments may not be able to be put in the pure “**Both should and should not**” phraseology, their ironic essence is quite close to pure paradox. Since critical thinking is a central goal of the lesson, any step outside of adherence to one’s perspective is celebrated.

### For Naught

We then move to the fourth side of the pillow, “**Neither A nor Not-A.**” This step sounds the toughest, but as evidenced by relative number of perspectives in support of it, it seems that the third perspective is actually harder. I ask them to do their best to pose all of the arguments in support of the statement that “we as a society **neither should nor should not** drastically cut welfare.” If I prime the pump with a short reminder of the “Pentagon as the largest source of wasteful spending in the federal government with \$7,600 coffee pots, \$9,600 Allen wrenches and \$640 toilet seats,”<sup>26</sup> people jump in with other examples, principally of Corporate Welfare.<sup>27</sup>

The issue is a false one because the real issue is corporate greed and not petty theft by individual recipients: Tobacco subsidies,<sup>28</sup> milk subsidies,<sup>29</sup> highway subsidies for truckers,<sup>30</sup> airport construction for American airlines,<sup>31</sup> and military contracts of little merit make the welfare program look like small change. “[P]ork doled out to forest products companies, agri-business, big banks that lose international bets, etc., probably comes to \$130 billion annually or more.”<sup>32</sup> By comparison, individual welfare constitutes 1% of the Federal budget or \$12 billion.<sup>33</sup> “Taken together, AFDC spending, food stamp benefits and Medicaid for AFDC recipients made up less than 5 percent of all entitlement spending, and not quite 3 percent of the

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total federal outlay.”<sup>34</sup> Let us deal with the real problem before we attack a tiny problem. The cost of the welfare bureaucracy is the problem, not the costs of supporting recipients.

There has been an amazing wealth of paradoxical perspectives that have come from this discussion over years that I have taught this module, of which the “false focus” ideas above represent only one tack:

What is the difference between the poor stealing from us and the government taking our money to give to the poor without our consent?

One of the strategies used by the rich is to make members of the middle-class conscious of how tenuous their positions are (one paycheck away from welfare) and then exploit that fear to drive a wedge between the middle-class and the poor. This is similar to the long-standing tactic of pitting poor “Whites” (“trash”) against (poor) “Blacks.” Who benefits? The rich! This is all part of a class war, which is based on individual greed.

What image do we get in the media? Welfare Queens, lazy people who will do anything to avoid work. What race is associated most strongly with that media image? African-Americans. What is the true history of “Black” women in America? In the slave era these women worked themselves *to death* in cotton fields. Even up to the modern era, “Black” women have worked to raise their own children and then gone to “White” homes to be nannies for “White” kids. How then do we suddenly have this image of “Black” women as lazy? Obviously, the

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welfare discussion is obscuring much of the true nature of things. It stands as a proxy for a race and gender discussion that we should be having instead.<sup>35</sup>

The Federal Reserve increases interest rates when unemployment falls below 6%. The logic here is that if there is too little unemployment, workers can demand higher wages, so corporations have to charge more for their products, so we all end up with spiraling inflation. But if the health of the nation depends on some people being unemployed, and ultimately falling off the unemployment rolls onto welfare, they are doing the country a big favor and should be rewarded for it.<sup>36</sup>

The issue is one of controlling women, the primary recipients of welfare. If women were paid as much as men were, there would be substantially less need for welfare.

Welfare keeps ambitions low, which suppresses revolution [that issue again]. So the issue is not welfare but class warfare.

“Instead of focusing on welfare or no welfare, we should be looking at the causes of poverty.”<sup>37</sup>

I love to enliven this discussion with a bit of theater, pounding on the table as I declare:

Now, we live in a society that has a strong work ethic. We are Amuricans (sic)! In Amurica you work hard, you make money, and you pull yourselves up by your boot-straps, by gummy! Isn't that the way of it? You bet! You work hard, you get ahead.

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But do you realize that there is a class of people who don't get paid for their work? We, as a society, demand that women provide child-care labor for free. Those women who work solely at home thus get no pay for their work. Is that American values? We say we believe in Family Values, but we do not back up that statement with our principal of pay for hard work done. If these child-care technicians were paid for their time, there would be no need for welfare. Are we saying that we should pay cooks who provide food for soldiers, for instance, but not pay those who cook for soldiers-to-be?<sup>38</sup> If mothers did not nurse sick children, nurses paid in excess of \$20 an hour would have to care for them.

Again, since critical thinking is a central goal of the lesson, I don't quibble with my students if they are not be able to put their arguments in a pure "**Neither\_nor**" phraseology. One may illustrate a form of this kind of paradox much closer to Nagarjuna's soteriological<sup>39</sup> goals:

Ultimately, the mind-set in which you can best embrace the statement that "we as a society **neither should nor should not** drastically cut welfare" is the mind-set you have when you see *that lion* (I point at a window) crashing through the classroom window.

The final step in our discussion is to affirm that there is just one reality (represented by the center of the pillow in **Figure 8**) from which each of these perspectives arises. "If you are sitting on *A*, you are missing much of the richness of this reality. If you are sitting on *Not\_A*, you are also missing much of the richness of this reality." I ask how many see this issue with a richness beyond what they brought to it today, and get an overwhelming, affirmative response.

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### Back to Our Original Question

Having now had some experience of using a paradoxical system of logic for a topic on which students generally feel themselves to be confident authorities, they more easily talk about wave-particle duality. In the first part of this paper we showed that light is a wave (A) and light is instead a particle (Not\_A), mirroring Nagarjuna's first two perspectives. From the third perspective, one can say that light **both** *travels like a wave* **and** *interacts with matter like a particle*, a perspective for which Sir Arthur Eddington coined the term *wavicle*.<sup>40</sup>

So what is the fourth perspective for light? I ask the reader to pull out a map of the city you live in and look at it carefully. Is this the city you know?

Likewise, I hold up a map of Portland for my students, and ask, "What is this? Is it Portland?" After a few students respond, "Yes," I confidently claim that "I am holding Portland in my hands." When they roll their eyes, I relent and say, "No? Oh, it is just a *representation* of Portland. We often make the mistake of believing that our thoughts about reality are that reality. Light is not 'a wave' or 'a particle' but a reality that has both wave-like and particle-like properties. Likewise, matter is not 'a particle' or 'a wave' but a reality that has both particle-like and wave-like properties." One student of mine<sup>41</sup> suggested that light in this aspect of its nature could be referred to as a "neithical."

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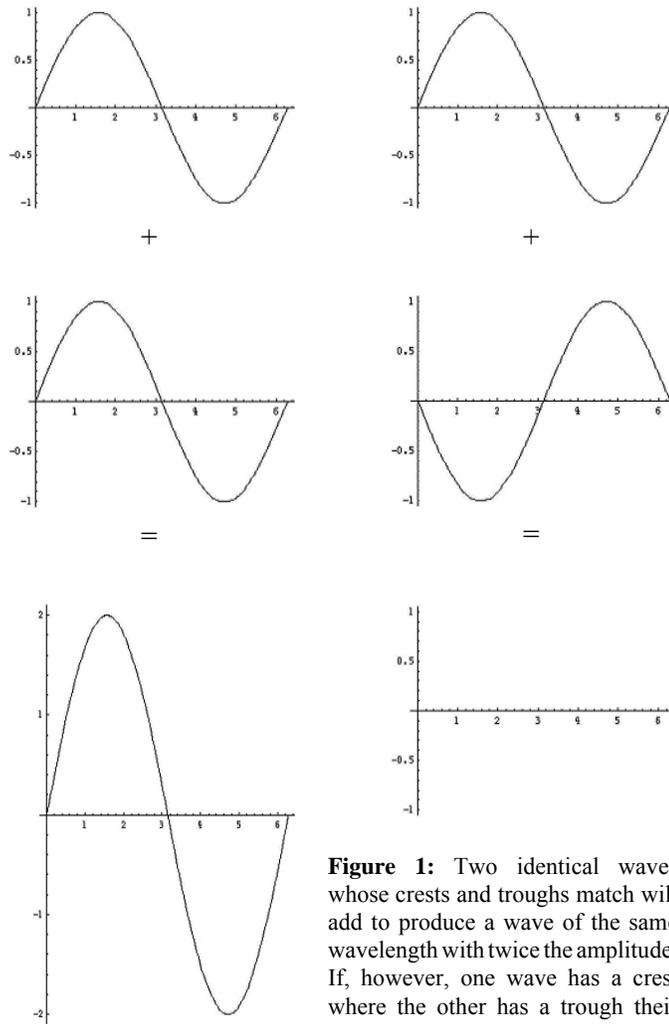
### **Hiding from Knowledge**

It is interesting that our journey into the richness of paradoxical thinking provides us with complimentary bounds on the nature of knowledge. Nagarjuna's fourth perspective reminds us to be humble in our perception of reality, of what we *can* know. The whole of this journey using Nagarjuna's Four-fold Proposition reminds us that much of our lack of knowledge is due to our own self-limiting: that we generally *block ourselves* from three-fourths of what we *can* know.<sup>42</sup>

This pedagogical tool facilitates the richness of learning that can be had from an interdisciplinary education. In the process of teaching the essence of the most difficult aspect of quantum reality, wave-particle duality, students have had to examine evidence for competing truth-claims. They have had to unpack and examine their value systems in the light of an opposing system that they have had to play-act. Their critical-thinking skills have been exercised far beyond the dualistic bounds shallow thinkers are apt to embrace. They have seen a new tool applied in two realms as far apart on conventional scales as can be, yet are generally comfortable applying patterns recognized in the first realm to understand the terrain of the second. Ultimately, they have to come to grips with the nature of knowledge and critique the degree to which they keep knowledge from themselves.

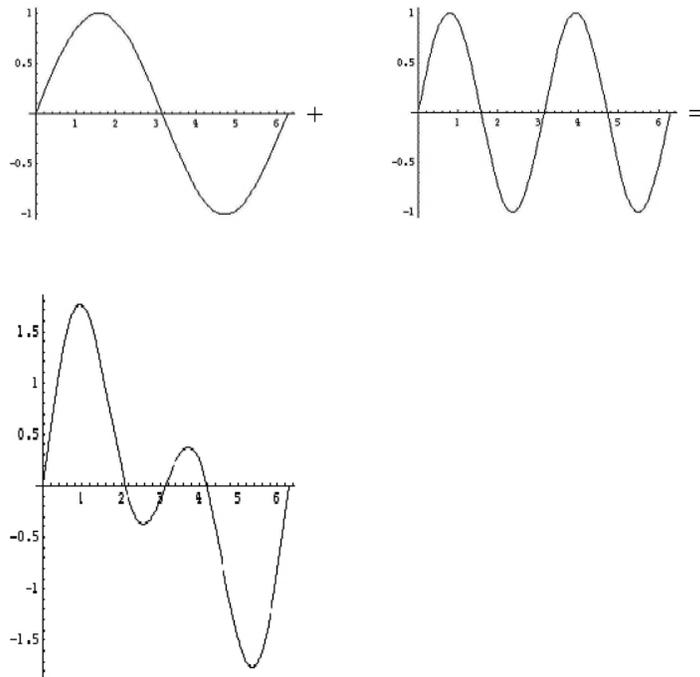
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Figures



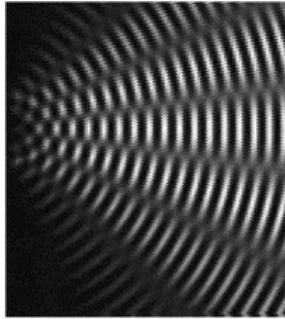
**Figure 1:** Two identical waves whose crests and troughs match will add to produce a wave of the same wavelength with twice the amplitude. If, however, one wave has a crest where the other has a trough their sum will be zero. This is called positive and negative interference.

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**Figure 2:** Plots of  $\sin[x]$ ,  $\sin[2x]$ , and  $\sin[x] + \sin[2x]$  as  $x$  ranges from 0 to  $2\pi$ .

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**Figure 3**

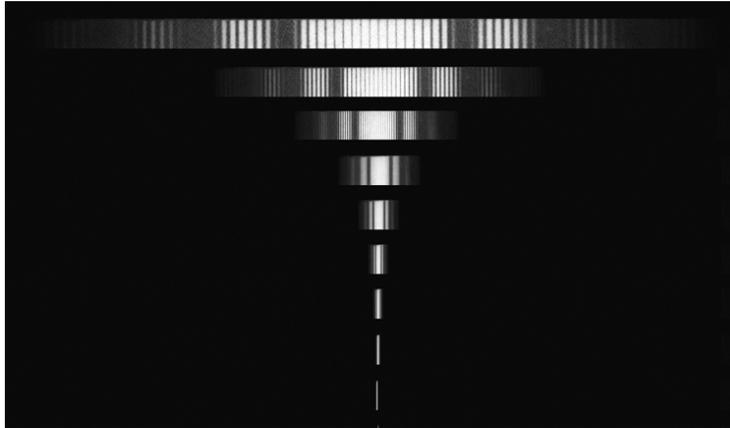


Light  
Dark  
Light  
Dark  
Light  
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Light  
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Light  
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Light

**Figure 4**

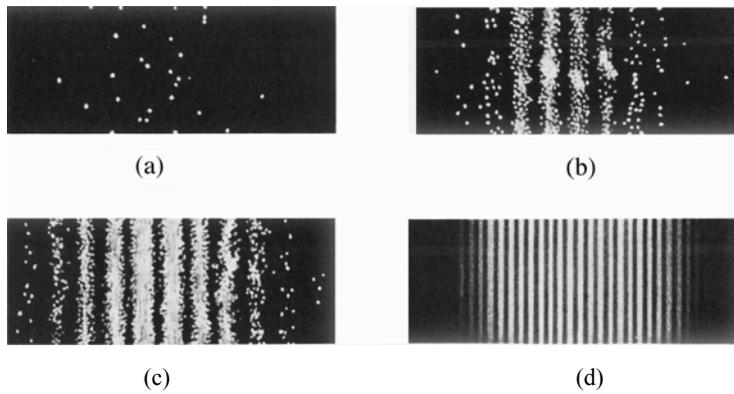
**Figures 3 and 4:** Waves in a ripple tank show a quilted pattern of interference of the two sources. A cross-section of the water's surface would show alternating troughs and crests along the line on the right side of the figure. Light moving down through the water will produce alternating light and dark regions. (Screen shot from Pisharody, 2002).

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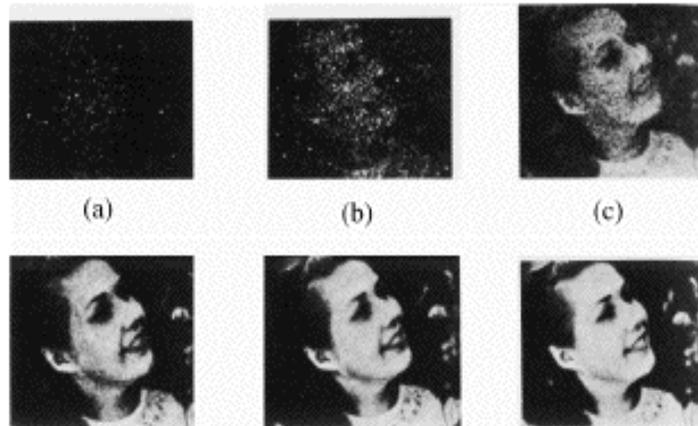


**Figure 5:** As the distance between the two slits gets wider (top to bottom), relative to the wavelength of the light, the interference becomes harder and harder to see.

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**Figure 6:** The double-slit pattern produced when a beam of electrons traverses a double-slit system and is captured on photographic film. (a) The pattern obtained when the film is struck by 28 electrons, (b) 1000 electrons, (c) 10,000 electrons, and (d) millions of electrons (or photons). (From Elisha R. Huggins, *Physics 1*, (Benjamin, New York, 1968), 510.)



**Figure 7:** Photons form an increasingly detailed image as more of them randomly traverse the optical enlarger as waves and then strike the photographic paper as particles: (a) 3,000 photons, (b) 12,000 photons, (c) 93,000 photons, (d) 760,000 photons, (e) 3,600,000 photons, and (f) 28,000,000 photons. Notice that in (b) one can see where the bright nose or cheek will be even though we cannot predict that a given photon will land there. We can also see that photons never randomly land in the eye socket. (Courtesy of Dr. Albert Rose) [Reprinted from *Seven Ideas that Shook the Universe*, Nathan Spielberg and Bryon D. Anderson (New York: John Wiley & Sons, 1987) 198.]

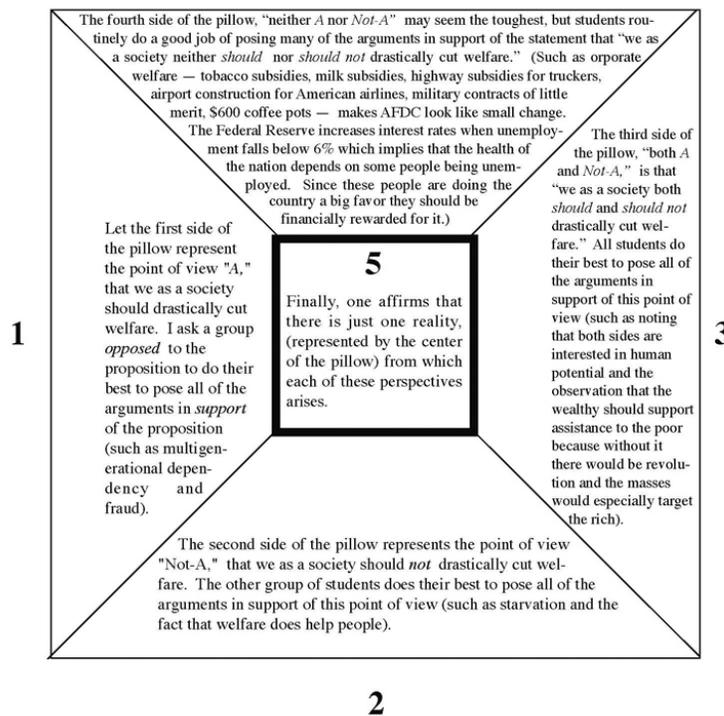
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**A pillow illustrating the paradoxical logic  
of the 200 B.C.E Indian philosopher Nāgārjuna  
with the social controversy over welfare.**

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**Figure 8:** A small subset of perspectives students come up with using Nagarjuna's logical system on the topic of Welfare Policy.

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### ENDNOTES

- <sup>1</sup> Santosh N. Pisharody has created a Java applet that nicely shows moving interference pattern  
<http://Galileo.phys.Virginia.EDU/~snp9b/java/Ripple.html>.
- <sup>2</sup> Centennial Printing-Out Paper from Chicago Albumen Works, PO Box 805, Housatonic, MA 01236, 413-274-6901).
- <sup>3</sup> Also known has his Catuskoti Logic, Tetralemma, and Four-Fold Negation of Propositions (the soteriologically equivalent negative form). The classic positive form of the proposition is found in Jay L. Garfield's translation and commentary; *The Fundamental Wisdom of the Middle Way: Nagarjuna's Mulamadhyamakakarika* (Oxford University Press, 1995) 49 (verse 8 of chapter XVIII, "Examinations of Self and Entities"), 249-51:
- Everything is real and is not real,  
Both real and not real,  
Neither real nor not real.  
This is Lord Buddha's teaching.
- <sup>4</sup> In *Metaphysics*, Aristotle says, "Again if when the assertion is true, the negation is false, and when this is true, the affirmation is false, it will not be possible to assert and deny the same thing truly at the same time. But perhaps they might say this was the very question at issue." (iv. 4. 1008a34-36.)
- <sup>5</sup> A philosophy founded on Emptiness is not monolithically "Eastern." Garma C. C. Chang, *The Buddhist Teaching of Totality: The Philosophy of Hwa Yen Buddhism*, (Pennsylvania State University Press, a University Park, 1986), pp. 90-1 notes:
- In direct opposition to the Buddhist emphasis on Emptiness or non-being, the Upanishads stress the primary importance of Being: "In the beginning, my dear, this was Being alone, one only without a second. Some people say, 'In the beginning this was non-being alone; one only without a second. From that non-being, being was produced.'

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But how indeed, my dear, could it be thus? . . . How could being be [91] produced from non-being? On the contrary, my dear, in the beginning this was Being alone, one only without a second,” (*Chan. Upa.* 6. 2. 2.).

<sup>6</sup> See, for instance, Garma C. C. Chang, *The Buddhist Teaching of Totality: The Philosophy of Hwa Yen Buddhism*, (Pennsylvania State University Press, a University Park, 1986), pp. 97-8:

In the third paragraph of the text of the Heart *Sutra*, we read: “Therefore in the Emptiness there are no forms, no feelings, conceptions, impulses, or consciousness; no eye, ear, nose . . . no ignorance and also no ending of ignorance; no old age and death . . . no Truth of Suffering, no Truth of the Causes of Suffering, of the Cessation of Suffering, or of the Path. There is no Wisdom, and there is no attainment whatsoever.”

In this paragraph we see that all the important and fundamental teachings of Buddhism are rejected: the five skandhas, the eighteen dhatus, the Four Noble Truths, including Nirvana and the holy Path; [98] are all abolished. Is this what the long-sought-after transcendental Wisdom has actually seen? Immediately the text says, “There is no Wisdom, and there is no attainment whatsoever.” So even Enlightenment and Buddhahood are finally scuttled. Now, is this Absolute Emptiness simply a synonym for nihilism? The answer is an emphatic No! Nihilism, in all its various forms, affirms the non-existence of some thing or some principle. But this affirmation itself is true and must be adhered to. In other words, it does not negate its own propositions as Absolute Sunyata [Emptiness] or Sunyata Sunyata [Emptiness of Emptiness] does. Sunyata Sunyata is not nihilism; it is absolute transcendentalism. The absolute is neither existence nor nothingness; it is simply inconceivable and indescribable through the conventional means of words and thought. To talk about it is to speak play-words! When one reaches this realm, there is simply nothing that can be said. This is why Vimalakirti kept silent when he was asked to describe the absolute (the Dharma-gate of non-duality).

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Here one is likely to raise the objection that the Absolute Sunyata is *meaningless* since it does not even assert its own stand. If one wants to say something meaningful at all, one must affirm whatever one tries to say; otherwise it would be much better to keep one's mouth shut! The astonishing Buddhist answer is that to say something meaningful, one does not have to affirm what he says. The speaker's remark was not made to assert a philosophical proposition but to bring his audience to the yonder realm to confront the Absolute face to face. Sunyata is not a doctrine of philosophy; if it is anything at all, it is a *therapeutic device* for the cleansing of men's innate clings.

If learning "critical thinking" is thought of as promoting "Enlightenment" in the sense of "The Age Of Enlightenment," then one may use a soteriological tool such as Absolute Emptiness [Sunyata] in an equivalent sense to help students in a public university setting divest themselves of unexamined presuppositions.

7

In *Dogen Kigen-Mystical Realist*, (Association for Asian Studies: Monograph No. XXIX, Univ. Arizona Press, Tucson, 1975) 115-6, Hee-Jin Kim discusses Dogen's clarification of the idea of the illusory nature of existence in Buddhist thought.

The word kuge. . . originally meant the "flowers blooming in the sky," that is, flowers which are illusory owing to man's dimmed vision (*eigen*). This term is changed by Dogen into "the flowers of emptiness" (the Chinese character *ku* means both the sky and emptiness). . . . Dogen is vehement in attacking the view that the flowers of emptiness will turn out to be non-existent when the eyes are cured of the disease [i.e., in enlightenment:]

. . . Just as all things themselves are ultimate reality (*shoho-jisso*), so are the flowers of dimmed vision. It is not a matter of past, present, or future; it does not concern itself with the beginning, middle, or end. Since it is not obstructed by birth-and-death, it truly allows birth-and-death to be as it is. [Things] arise in emptiness and perish in it; they come into being in the midst of it; and they are born in flowers and die in them. So do the rest of all things in time and space. (*Shobogenzo, Kuge* [The

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Flowers of Emptiness])

What concerns Dogen most is not to eliminate illusion as opposed to reality so much as to see illusion as the total realization—not as one illusion among others but *the* illusion, nothing but the illusion thought the universe, in which man can at last find no illusion. Only if and when man realizes the non-duality of illusion and reality in emptiness, can he deal with them wisely and compassionately.

<sup>8</sup> “What is that which always is and has no becoming; and what is that which is always becoming and never is? That which is apprehended by intelligence and reason is always in the same state; but that which is conceived by opinion with the help of sensation and without reason, is always in a process of becoming and perishing and never really is.” Timaeus, in *The Dialogues of Plato, Vol. II*, Tr. B. Jowett (Random House, New York, 1920), 3-70 at 12.

<sup>9</sup> Plato . . . having in his youth first become familiar with Cratylus and with the Heraclitean doctrines (that all sensible things are ever in a state of flux and there is no knowledge about them) . . . held that the common definition [of the universal in ethical matters sought by Socrates] could not be a definition of any sensible thing, as they were always changing. Things of this other sort, then he called Ideas, and sensible things, he said, were all named after these, and in virtue of a relation to these; for they existed by participation in the Ideas that have the same name as they. Only the name ‘participation’ was new; for the Pythagoreans say that things exist by ‘imitation’ of numbers, and Plato says they exist by participation, changing the name. But what the participation or the imitation of the Forms could be they left an open question. (Aristotle, *Metaphysics* i. 6. 987a29 - 987b13.)

The first of those who studied science say that none of the things that are either comes to be or passes out of existence, because what comes to be must do so either from what is or from what is not, both of which are impossible. For what is cannot come to be (because it *is* already), and from what is not nothing could have come to be (because something must be present as a substratum). . . .

Our explanation on the other hand is that . . . [a] doctor builds a house, not *qua* doctor, but *qua* housebuilder. On the other hand he doctors or fails to doctor *qua* doctor. . . . Clearly then also ‘to come to be so-and-so from not-being’ means ‘*qua* not-being’....

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We ourselves are in agreement with them in holding that nothing can be said without qualification to come from what is not. But nevertheless we maintain that a thing may 'come to be from what is not'—that is, in a qualified sense. For a thing comes to be from the privation [in a substratum of the Form], which in its own nature is not-being-this not surviving as a constituent result. . . .

In the same way we maintain that nothing comes to be from being, and that being does not come to be except in a qualified sense. . . . Thus, suppose a dog to come to be from a horse. The dog would then, it is true, come to be from animal (as well as from an animal of a certain kind) but not as *animal*, for that [Form] is already there. (Aristotle, *Physics* i. 8. 191a23 - 191b24, emphasis in original.)

<sup>10</sup> Nagarjuna might be as apt to say "there is no reality from which these perspectives arise," and/or list the four perspectives as (i) neither A, (ii) nor *Not\_A*, (iii) nor **Both A and Not\_A**, (iv) nor **Neither A nor Not\_A** (See, for instance, Jan Straathof, "Logical Meanderings between West and East: Aristotle, Nagarjuna and Bhaskar," *Alethia*, Issue 2:3, November 2000, who describes how this logic might be applied to the Middle East.) But these two constructions are not different. As Garma C. C. Chang, in *The Buddhist Teaching of Totality: The Philosophy of Hwa Yen Buddhism*, (Pennsylvania State University Press, a University Park, 1986), notes:

. . . [T]here are two basic reasons why Absolute Sunyata [Emptiness] cannot be equated with nihilism: first, it is self-negating or self-transcending as we have just seen; second, it plays an indispensable role in "supporting" all dharmas. Because of Sunyata, all things can exist; without Sunyata, nothing could possibly exist. Sunyata is therefore extremely dynamic and positive; in the words of the *Heart Sutra* this is called "Emptiness is form." (pp. 90-1)

Put slightly differently:

*Sunyata, therefore, should not be considered to be a something which somehow exists somewhere.* One has to rise above his intellectual habitude to perceive it. On the other hand, if one does not cling to Emptiness, he cannot be accused of being nihilistic. A famous koan of Zen master Chao Chou is a good illustration of this point:

A monk asked Chao Chou, "What should one do

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when there is not a thing to carry?" Chao Chou looked at him and said, "Lay it down!" The monk said, "Since there is nothing at all to carry, what should I lay down?" Chao Chou said, "In that case, then take it up!" The monk was immediately enlightened.

At the outset the monk had already attained some kind of shallow realization of Emptiness, but he clung to it and could not free himself to play in the dynamic flow of events. He still had the perplexity of what to do next. Chao Chou, the truly enlightened master, saw this right away; so he said to him, "Lay it down," meaning lay down your so-called Emptiness. But the monk, who was deeply involved in the dead-emptiness, fought back by saying, "Since there is not a thing to carry, what should I lay down?" Chao Chou replied, "In that case, then take it up!" This totally unexpected remark awakened the monk from his dead-emptiness and brought him to true Enlightenment. The critical point to notice in this dialogue is the last remark, "Take it up," because by freeing oneself from clinging to the dead-emptiness, one can participate in every activity in the world without losing the Sunyata insight. After all, form is Emptiness, and Emptiness is form, and there is not the slightest difference between them. (p. 99)

<sup>11</sup> Created in 1935.

<sup>12</sup> Ellen Goodman, in her article "America's New Women's Movement: Off The Welfare Rolls and Into Poverty" (*The Oregonian*; Portland, Or.; Aug. 8, 1999 F5 ), is generally supportive of welfare, but in this phrase she concisely encapsulates the kernel of thinking in some of those who oppose welfare.

<sup>13</sup> In 1996 12.8 million people were on welfare, of whom 8 million were children, Bassuk at 60.

<sup>14</sup> In March 1987, the General Accounting Office released a report that summarized more than one hundred studies of welfare since 1975. It found that "research does not support the view that welfare encourages two-parent family breakup" or that welfare significantly reduces the incentive to work. Conservatives also accuse welfare of giving mothers an economic incentive to have more children. Ten

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major studies have been conducted on this issue in the last six years alone, and not one has found any connection between the level of payments offered and a woman's decision to bear children. The size of average welfare families is virtually the same as non-welfare families

(<http://www.scruznet.com/~kangaroo/ShortFAQ.htm#welfare>).

15       “From talking to people,” explained Sandra Morgen, director of the university’s Center for the Study of Women in Society and an author of the report, “it’s very clear that food is perceived as a kind of discretionary expense. It’s easier to go hungry than to be evicted.” So we’ve got a hunger program that works best if you consider eating to be optional.’ David Sarasohn, “New Finding: Without Food, Folks Don’t Eat,” *Newhouse News Service*; Washington; Mar 16, 2001.

16       ‘States punish people not only for failing to participate in work programs, but also for mundane offenses. In Texas, 57 percent of the people who left welfare last year were removed because they did not keep appointments or failed to “provide complete information.” Laura Meckler (AP), “Welfare Ranks Thin As Rules Toughen,” *The Oregonian*; Portland, Or.; Mar 29, 1999, A2. In Arizona, 60 percent are taken off welfare because they do not appear for a welfare interview.’

17       Luke 12:48, NIV

18       Bassuk at 62.

19       Bassuk at 66.

20       Bassuk at 67.

21       Bassuk at 67.

22       Bassuk at 62.

23       Bassuk at 62.

24       Laura Meckler (AP), “Top Firms Unwilling To Hire Those On Welfare,” *Oregonian* (May 26, 1997), A19.

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- <sup>25</sup> In the chaos of facilitating a discussion like this, I often forget to take attribution notes. This is one exception, from my student Lindsay Wagner, Senior Inquiry, Westview High School, Spring 1999.
- <sup>26</sup> Felicity Barringer, "Whistle Blowers Get Few Federal Bonuses; Bill to Renew Reward Plan Is on Hill," *The Washington Post*, March 5, 1985, A13.
- <sup>27</sup> "The federal government currently spends \$75 billion a year on direct subsidies to business. Last year both Congress and the Clinton administration pledged to attack that pervasive corporate safety net. This study finds that those promises have been largely unfulfilled. Of the \$19.5 billion budgeted for the 35 least defensible programs, Congress cut just \$2.8 billion in 1996. That was a 15 percent cut from the 1995 level. Eighty-five percent of corporate welfare spending survived. (HOW CORPORATE WELFARE WON: Clinton and Congress Retreat from Cutting Business Subsidies by Stephen Moore and Dean Stansel [Cato Policy Analysis No. 254 May 15, 1996, <http://www.cato.org/pubs/pas/pa-254.html> accessed 12/12/01.]).
- <sup>28</sup> \$1.6 billion a year in tax deductions for tobacco advertising and \$ 77 million a year in tobacco subsidies. Arianna Huffington, "I'd rather fight than switch to tobacco's side," *Chicago Sun-Times*, October 28, 1998 [Editorial], 47.
- <sup>29</sup> \$679 million a year, according to U.S. Agriculture Secretary Dan Glickman. Donna Halvorsen, "Judge Doty grants delay of his ruling scrapping U.S. milk pricing system; Stay will keep subsidies stable for now," *Star Tribune* (Minneapolis, MN), December 6, 1997, 14A.
- <sup>30</sup> "Federal highway subsidies have doubled since 1982, from \$14.4 billion annually to \$29 billion." James O. Goldsborough, "A question of the government's misplaced priorities," *The San Diego Union-Tribune*, June 21, 2001, [Opinion] B-11:2,7; B-7:1; B-15:6
- <sup>31</sup> "The federal government will spend nearly \$ 40 billion on improvements at airports of all sizes during the next three years." Steven Gray, "Outlying Airports Signal for Flights; Terminals See Major Upgrades," *The Washington Post*, December 18, 2000, B01.

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- 32 Don Bauder, "Corporate pickpockets show no sign of leaving the  
trough," *The San Diego Union-Tribune*, April 2, 2000, I-2.
- 33 "\$12 billion last year, or less than 1 percent of the federal budget.  
Counting the share paid by states, AFDC cost \$ 22 billion." Dave  
Hage, "Questions and answers on welfare: who's on it, what does it  
cost?" *Star Tribune* (Minneapolis, MN), December 15, 1996, 37A.
- 34 Bassuk at 67.
- 35 On the other hand, discussions of race generally overlook the  
important issues of class.
- 36 David Sarasohn, Editorial: "Unemployed Are Real Public Servants,"  
*The Oregonian*, May 4, 1994, D10.
- 37 My co-teacher, Barbara Traver, Senior Inquiry, Westview High  
School, (personnal communication, Spring 1999).
- 38 Indeed, in one study, "59 percent cited unavailability of affordable  
child care as a barrier to work." Bassuk at 66.
- 39 The branch of philosophy that describes techniques for realizing  
cosmic enlightenment.
- 40 Simon Altmann, "The new enemies of rationalism"  
[http://www.iheu.org/new\\_enemies\\_of\\_rationalism.htm](http://www.iheu.org/new_enemies_of_rationalism.htm).
- 41 Spring 1997.
- 42 It would be interesting to treat these two as the first two perspectives  
of Nagarjuna's Four-fold Proposition on Nagarjuna's Four-fold  
Proposition, and inquire into what the third and fourth sides of *that*  
proposition look like.