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Science and the Turin Shroud

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Preface

I know that you were expecting Paul Nicholls and he was disappointed not to be able to be with you and sends his apologies. I have known Paul since 1985, when he lectured us in toxicology, when I was an Applied Chemistry undergraduate at Cardiff University. The following year, I began a Ph.D. in Pharmacology under his supervision. Until recently, the "Turin Shroud" was just a vaguely familiar name to me. Then Paul showed me the evidence and I was immediately interested in this phenomenon that was the subject of such intense multi-disciplinary research and debate and I decided to examine the arguments.

Introduction

The audience is probably unfamiliar with the principles of scientific discourse. I think that from your point of view, it will be helpful if I were to begin by presenting you with an exposé of scientific thinking with particular reference to its limitations, so that you will be in a better position to judge the scientific evidence for yourselves.

Later, I shall concentrate on one area of evidence concerned with the Shroud; that of radiocarbon dating, discussing how and what radiocarbon dating can and cannot tell us.

I should add that I have no biases regarding the Shroud's authenticity. And frankly, this wouldn't make any difference to me one way or the other. However, it is clear that the Shroud does exhibit some intriguing characteristics and I would like to see the same rigorous analytical procedures applied to it as any other object and conclusions based on what is probable, not what it is claimed to be. In fact, l think that if it weren't for the claims associated with the fabric, the conclusions would be clearer because all parties concerned would simply wish to describe what is rather than shifting their perspective to what they do or do not want it to be.

The Nature of Scientific Evidence

Since I have been asked to approach this from the perspective of the scientific community, I will begin with a brief overview of what scientists believe in: the scientists' religion, if you like.

Just like any other human population, the scientific community reflects the diversity of our species. As such, it too has fervent believers, but relatively fewer sceptics. Curiously, fewer people question scientific evidence as opposed to other evidence [historical, or anecdotal, or observations not subjected to scientific scrutiny]. Yet, scientific evidence is also prone to misinterpretation.

The scientific "Commandments", called the scientific method, is designed to guard against misinterpretation or "jumping to conclusions" and, on the face of it, there isn't much criticism that can be levelled against it.

The Scientific Method

First, we must have an observation, such as: Some people have blue eyes and some people have brown eyes. Some people have blond hair and some people have brown hair. Then we ask a question: Is there a relationship between hair colour and eye colour?

We then make a hypothesis (that is a, hopefully educated, guess): More people with blond hair have blue eyes than brown hair. (if we cannot measure all of the population, because it is too big or changing, we would need to talk about the likelihood, because we can never *know* what is going to happen. So we would restate our hypothesis thus: People with blue eyes are more likely to have blond hair than brown hair. Note that the hypothesis is a possible answer to a question which is much narrower than the original question and one that can be measured directly (in this case, by counting each group).

This is another one of the scientific commandments: The hypothesis must be specific, measurable and must have a "true or false" answer. There is a school of thought that says that: If it is not possible to design an experiment so that if the hypothesis were false, it would clearly show it to be false, then it is not a good hypothesis. This is called "falsification." For example, the hypothesis that "objects are all black until light shines on them" not a good hypothesis, because if this hypothesis is false, it is not possible to design all experiment to show it to be false. Then comes the experimental design. Our experiment must give a true or false answer to our hypothesis. Here, we run into two other commandments:

The experiment must be reproducible: This means that if someone else, somewhere else, does the same experiment, they should get the same answer. This is another good reason for the hypothesis to only have a true or false answer.

The other commandment is that the experiment must be fair. The very word fair implies that we must compare, and we must compare *like with like*. So far, it all seems quite straight forward and it seems that there can be no objection to this procedure. However, it is on the interpretation of the word "fair" where science and humanities meet! Nearly all arguments amongst scientists stem from the concept of what is a fair experiment. That's why the more sceptical (who perhaps prefer to be known as the more "open-minded") scientists identify more with scientific theories than scientific facts.

I will try to illustrate this with our "blue-eyes" example:

How call we design an experiment to see whether people with blue eyes are more likely to have blond hair than brown hair.

I could start by counting the number of blond-haired and blue-eyed people in this room and compare that with the number of blue-eyed people who do not have blond hair ... Straight away, I would have a problem. My hypothesis says "people with blue eyes are more likely to have blond hair than brown hair." By just counting the blue-eyed blond and blue-eyed non-blond, I will have assumed that all non-blond-haired people have brown hair. In this case, we can count the number of blue-eyed brown-haired people too.

But sometimes, our measuring equipment can only see one part of the picture and we don't have the luxury of counting all of the separate populations. That is to say, because of the limitations of the circumstances under which we make our observations, we may have to make a broader hypothesis, for example in this case "people with blue eyes are more likely to have blond hair than not have blond hair." [e.g. cell staining]

Coming back to our experimental design, we've decided to count the blond-haired and brown-haired people. Now we have to say what we mean by blond and brown and even blue. Because if disagreements arise because of definitions, then the experiments won't be reproducible. So, what's the darkest colour that we can class as blond? How are we going to measure the hair colour? Are we going to take a single strand, and average of several strands ... which part of the head? etc.

Our next problem is that we still need to compare like with like. What if we find that we are more likely to see blue-eyed people amongst blonds but also find that our sample of blonds had more blonde women than blond men? Then it is possible that we counted more blue-eyed people because being blue-eyed is linked to sex not to hair colour. To account for this and to make the experiment "fairer", we must have the same number of men and women in each group. Then if eye colour is linked to sex, then we would get enough mix between the two sexes to be able to say that it is NOT linked to hair colour and so to answer "false" to our hypothesis.

If we wanted to test for sex as well, we would need to write a different hypothesis and then use the data in a different way to answer true or false to our new hypothesis. Notice how it is up to the individual scientist (or group of scientists) HOW he states his hypothesis which decided the direction of the experiment and the nature of the evidence.

If my hypothesis had been "people with BROWN eyes are more likely to have brown hair, then my experimental design would be centred around the investigation of brown eyes, not blue. Although, on the face of it, it may appear that this will not make much difference, in practice, it may.

You may find an equal number of brown-eyed people in both blond and brown-haired populations, but a different number of blue eyed people in those populations. The reason for this would be that some people may not be classed as brown-eyed or blue-eyed, but this group may be mainly in brown-haired or blond-haired populations.

To comply with our next commandment, we would need to make sure that our results are reproducible. This means that if someone in America repeated our experiment, they should get the same result. But it is possible that they won't because they may be using a different ethnic mix of people. So, either we have to specify the population and ethnicity of our sample, or we have to take a much wider selection for our sample to account for all possible groups. Notice that the idea of "sample" itself implies a calculated guess. The colour of hair, the ethnicity, the geographic location, the season, age, and vague things like "mood" MAY affect eye colour. In all cases we must make sure that our sample is representative of the group we have specified ["representative", now there's another potentially contentious issue, generally arbitrated by statistics!] Often these so-called variables are not so obvious and experiments performed in one place cannot be reproduced elsewhere due to factors that have not been reported and that's when sparks begin to fly!

This narrowing down of the conditions of the experiment to make sure that we have assumed as few uncontrollable things as possible is one of the main reasons why scientific papers appear to be so technical to anyone outside the field. Each group of scientists working in any area are aware of the limitations of their experiments (hopefully!) and the technical bits tend to be the descriptions of these limitations. e.g. which instruments were used, which methods of analysis were used, how certain criteria were defined and so on.

In simple terms, the argument goes something like this: If you do something, a lot of things are affected. If you do less, fewer things are affected. The ideal situation would be to do so little that only one thing gets affected. Unfortunately, this seems to be impossible, because as the famous man, uncle Albert, said: everything is relative!

Let's illustrate this with another simple example:
Question: What determines how fast a piece of paper falls to the ground? Hypothesis: Larger surface area makes it fall more slowly.
Experimental design: Need pieces of paper with differing surface area, but the same mass, density, colour and surface structure, thickness, shape (and same everything else that I can think of!). I can't think of any experimental design that will answer a straight true or false to this, simplest of hypotheses.

Fact or Fiction
The closest thing we get to scientific "fact" is what we define. Everything else that we *call* scientific fact is "proof *beyond reasonable doubt*" and that reasoning is bound by the limitations of our experiences, which themselves vary from person to person. From now on, when I use phrases that imply "fact", like "we know that ... bear in mind that I mean, either that it has been *defined* that way, i.e. that we have all *agreed* to call it something.

For example, if I say that this piece of paper is white, we may not know exactly what white is, and if I were to see what you see, I may not even recognise it. But, we agree that, when compared with other colours, it is different and that difference we will *agree* to call white. On the other hand, there may be is so much *evidence* in favour of a particular *theory*, that we all *agree* that it is true. [When we agree, then it becomes "objective" even though it is only "collective subjectivity"]

Something else that we don't do, especially if we are in agreement, is to question our perceptions when we are observing *our* universe. But, *our universe* only looks and feels the way that we sense it because of the limited facilities that we have for sensing it.

Laws and Theories
A theory is a hypothesis that many (well designed) experiments have *not shown to be false*. If there is just one piece of evidence against a theory, then we normally need to redefine the limits of our theory. Although, sometimes we believe in our theories so much that we dismiss the evidence as an "error" or mistake or if we want to keep an open mind (against our better

judgement!) then we call it an "anomaly" and forget about it until it is reported again and again. Then we start by arguing against the anomalies!

If we haven't had to redefine the limits of our theory for a very long time, then it gets to be promoted to the status of "law". Like the law of gravity or the law of conservation of mass and the law of conservation of energy, [for people who like to make things sound more complicated than they are, the last one is also called the "first law of thermodynamics!”

But even these natural laws are based on the sum of human experience. But suddenly, some brave person could come along and say "the reason millions of you believe this is because you haven't experienced anything else" or "... because you haven't thought about it in any other way." Einstein falls into the first category and Galileo into the second. Galileo said that the reason you think everything goes around the earth is that you haven't thought about the possibility that everything else is standing still and the earth is moving around itself.

Uncle Albert said that the law of conservation of mass and the law of conservation of energy is OK when your experiences has only dealt with big things, but if you get the nucleus of an atom and split it into two parts, then the sum of the two parts will be less than the original. The difference has changed into energy and the amount of energy is governed by $E=mc^2$. I've only scratched the surface, here, but I hope that it gives you some insight into some possible pitfalls in science. So, when Chief Engineer Scottie says to Captain Kirk "I canno' change the laws-o' physics" what he means is 'I can only think within the limitations of the sum total of my experiences’!

With these in mind, let's look at what radiocarbon dating is all about. What we are told in school chemistry lessons is that all the various types of objects that exist on earth are made up of just 92 natural building blocks that we call elements and that water is made up of two TYPES of these building blocks in the proportion of 2 parts hydrogen and 1 part oxygen. Oxygen is 16 times heavier than hydrogen, so we can say that hydrogen has a mass of 1 and oxygen has a mass of 16.

As well as their mass, each element is also given a number. So that oxygen isnumber 8, carbon is number 6 and hydrogen is number 1. What these building blocks, or elements, can do, in terms of forming all the objects that we see around its, depends on their number and not their mass. So, we think it is like a square peg still being a square peg no matter what its weight is.

If they are essentially the same element, but have different masses, we call them "isotopes". Atoms of a certain number prefer to be a certain mass. So, carbon whose number is 6 prefers to have a mass of 12 and it can cope with having a mass of 13. We say that carbon 12 and carbon 13 isotopes are stable. (in fact, 98.89% of naturally occurring carbon is carbon 12 and 1.11% - which is virtually the rest of it - is carbon 13).

When carbon has a mass of 14, it doesn't like it and is unstable. All unstable isotopes are radioactive (hence the name "radiocarbon"). That means that they want to change and become something else that is more stable. When the element nitrogen has a mass of 14, it is stable. So, carbon 14 changes itself to nitrogen 14 and in the process, throws out a radioactive particle. This happens gradually and depends on how stable the atom is (or at least, that's how we think of it).

Now, what are the chances of a C-14 atom decaying to N-14? ... We haven't got a clue! We can't see atoms and we don't know what they do as individuals, but when we have millions upon millions of them, we can do some fairly reliable statistics.

In astronomical terms, the age of the earth is fairly insignificant and it is being constantly bombarded with cosmic rays. Astronomically speaking, this could just be a quick burst, but to us, it translates as millions of years (sobering thought, isn't it?). These cosmic rays convert a certain proportion of stable atmospheric N-14 (80% of our atmosphere is nitrogen) into unstable C-14. Over the millions of years, the rate of formation of C-14 has come to match its rate of decay, so that at any one time, the proportion of C-14 to C-l2 and C-13 is constant. The proportion of C-12 to C-14 in the atmosphere is 1 million million to 1. That's one with 12 0's in front of it to 1. This may seem very little but when we realise that just 1 gram of carbon has 5 with 22 0's in front of it of carbon atoms, then it means that in just one gram of carbon we have fifty thousand million unstable C-14 atoms. We can't say how long it would take for one atom to decay, but we can say that if we seal that gram of carbon in a vault and leave it for 5570 years, then half of it will have changed to nitrogen. We know this because we can count the number of radioactive particles given off in a set period of time. In another 5570 years, the radioactivity will have halved again.

Now, that's how we can date some carbon that we can lock away in a vault, but what about historical or archaeological artefacts? These are based on the idea that living organisms recycle carbon [unless they are industrialists!]. Living plants take CO_2 from the air and with the help of water and a few minerals from the soil, convert it into leaves, branches, stalks, seeds, fruits and fibres. Animals eat these plants, taking in the same carbon and convert it into flesh and excrement. Dead organisms don't do these things. So, material from dead organisms stops being recycled and if they don't decay, we have our vault. By comparing the ratio of unstable C-14 to stable C-12 or C-13, in the sample, with that in living organisms (or recently dead ones) and knowing that the radioactivity of billions of carbon atoms drops by one half every 5570 years, we can hazard a guess as to the age of the sample - IN THEORY!

In this process, we have to make a number of assumptions, and we must vigilantly check to make sure that our assumptions are valid. Here is a list of assumptions that I can think of:

<u>Assumption 1</u> - The ratio of C-14 to C-12 (or C-13) is constant over the period under investigation. If there is any question about this, then it must be sorted out. Dr. Kouznetsov has suggested that there is insufficient evidence to be certain about this and that there may be alterations due to variations in. solar activity and even geographic location.

<u>Assumption 2</u> - All of the carbon in the sample is of organic origin. If not, the age would appear older, not younger. For example, in carbon-containing minerals, such as diamond and graphite, the carbon atoms will have been fixed in place for millions of years, so there will have been no recycling.

<u>Assumption 3</u> - The carbon content of sample has remained unchanged since its formation. With most archaeological findings, samples can be taken from below the surface of the object and we assume that organisms will not have contaminated this region. But this assumption is not so valid with an artefact with no depth as far as sampling is concerned, such as the Turin Shroud. Also, this object has not been protected from other organisms, such as man! To overcome this

problem, we would need to wash the sample in such a way that only the organic fibres attributed to the origin of the sample remain for analysis.

The evidence presented by Dr. Garza-Valdez, calls this assumption into question. He provides evidence of a plastic- or resin-like substance of organic origin (biopolymer), produced by micro-organisms, forming a coating over the fabric of the Shroud. It has been stated that this polymer is resistant to the normal radiocarbon dating washing procedures. Two questions arise [which means that there are 2 questions that immediately spring to MY mind!]. Firstly, to affect the carbon dating results, the polymer would have had to have been formed hundreds of years after the manufacture of the cloth, so the question is when and why so late? [I know, that's 2 questions]. The second questions stems from the concept that all living systems must eat (or assimilate, if you are a biologist!), this includes bacteria. It has been proposed that "during the first century A.D. in the area of Palestine, sodium carbonate was used in the bleaching of linen as well as an important ingredient in perfume and resins(myrrh) used for burial). If the bacteria assimilated carbon from sodium carbonate, then, as I mentioned earlier, minerals don't have their carbons recycled, so the bacteria would be making their biopolymer from radiocarbon deficient food. This would result in the dating being older, not younger. If the bicarbonate was derived from organic origin and if we say that the bacteria also assimilated the perfumes and resins that were put on the Shroud, then those materials also came from carbon in the first century, in which case, the carbon dating would not be affected. The biopolymer would have had to have been formed well after the fourteenth century for it to give a date around that time. This is because you would still have some material from the first century, which would be poor in C-14 and some material which would be rich in C-14, which together would give an average leading to a dating of 1200 to 1400 A.D. In fact, this would have to be the case for all arguments, based on contamination. 14th century contamination of first century cloth would give a carbon date of somewhere between 1st and 14th centuries. If the biopolymer was formed after the 14th century, the question arises; what post 14th century food did the bacteria eat?

<u>Assumption 4</u> - The sample taken for analysis is representative of the whole sample. As a matter of course, we must make sure that we take samples that are representative of the whole material. However, the importance of this becomes much more apparent when it is clear that the object is non-uniform. The obvious way to do this is to take samples from different regions of the object and compare the results. If they match, there can be said to be good evidence that the object is from the same time period. If they do not match, then we need to take many more samples from different regions of the object to establish the pattern of discrepancy [hopefully, there will be a pattern!] so as to be able to provide a theory for the source of the anomalies. Of course, if the object is precious, then this kind of sampling may not be warranted.

However, a serious charge, in scientific terms, that has been levelled at the carbon dating studies is that of inappropriate sampling. This in itself is reason enough to question the results.

<u>Assumption 5</u> - Living organisms are just chemical works and cannot differentiate between carbon isotopes. i.e. the ratio of C-14 to C-13 or C-12 reflects atmospheric ratios.

This was an assumption that wasn't questioned until recently. As I mentioned before, we know that the chemical behaviour of atoms depends on their number and not their mass. But there is a lot that we don't know. [in fact, in relation to what we don't know, what we do know can be mathematically shown to be absolutely nothing; but that's just by the way] Nevertheless, not long ago, when I first heard the idea of isotope biofractionation in flax, as proposed by Dr. Kouznetsov, I was sceptical, so I searched the literature to see if there was any other evidence of this sort of thing happening in any other living system. I was surprised to find a few. There appears to be evidence from a number of studies from a number of locations (by a number of people!), that suggest that living organisms, including humans, can select for lighter or heavier atoms of the same element, such as carbon or nitrogen (so-called. isotope biofractionation).

I have found reports that:
a) some bacteria can fractionate nitrogen isotopes. (Wattiaux MA. Reed JD. *J. Anim. Sci.*; 73(1):257-66, 1995.
b) Over a period of 20 to 30 days, carbon isotope oscillations of up to 6% can occur in human hair. (Ivlev AA, et al. *Biofizika*; 37(6):1090-5, 1992.)
c) [and this is an interesting one for this group] "Variations of carbon isotope composition of hair taken from faces of three men with different health state were studied. Drastic enrichment (up to 20%) of hair carbon-14... was discovered in one of the men under test. This enrichment correlated with his worsened state of health. Then carbon isotope composition of the hair returned to the background level. Probable explanation of this correlation was suggested in terms of earlier described mechanism of carbon isotope fractionation in the living cell. (lvlev AA, *Biofizika*: 37(6):1086-9, 1992.)

Hence, it appears that we have to look again at the idea that living organisms are just chemical works, because they seem to understand a little about the physical as well as the chemical character of the atoms that they are dealing with. I think we have a very long way to go before we understand why they might make such a distinction. But at any rate, Dr. Kouznetsov's idea that flax could biofractionate carbon isotopes becomes, at least, possible.

I have recently read a number of Dr. Kouznetsov's reports. With reference to the published title of this address, I will present you with some of my impressions of his work. In his papers, Dr. Kouznetsov has argued for:

1. Biofractionation of flax fibre,
2. Heat modification of C-14 content,
3. Variation in heavy carbon isotope content in different contemporary flax,
4. C-14 values are not constant due to variations in solar activity and geographic location.
5. Lost/archaic cellulose modification methods,
6. Microbial contributions of carboxylating enzymes derived from normal autolysis of air and soil micro-organisms.

Let's consider each of these in turn:

1. We've said [well actually, I have said!] that the biofractionation of radiocarbon seems possible, but we need to have evidence to show that it does happen in flax. In one of his papers, Dr. K states "...However, this assumption is open to question because of the known phenomenon of biological fractionation of carbon isotopes by living plants which leads to the significant enrichment of the textile by C-13 and C14 isotopes during flax spinning in the manufacture of linen." I had to think a while to get my brain around what was being suggested here because it

seemed that the flax spinning process was somehow leading to a C-14 enrichment in the fibres, which seemed bizarre. [semantics like that could get a scientist into trouble!] Fortunately, with the help of the rest of the paper, I understood this to mean that: If the flax plant concentrates its C-14 in its cellulosic structures (which includes the fibres) then, since flax spinning involves the separation of the cellulose in the plant, then this fraction would have more C-14 than the whole plant average.

He also states that "It has been shown that not less than 60% of the total amount of C-14 atoms in the flax body is concentrated within the cellulose fraction." I am not sure whether this is a problem of phraseology or not. However, I wouldn't be at all surprised if it were found that not less than 60% of the flax body IS cellulose. In which case, it would be fairly logical that not less than 60% of the C-14 would also be there. This statement was referenced to a 1986 and a 1993 paper which I would need to study before I can be clear on this point.

2. Heat modification of C-14 content,

The principal argument around this theory is that under the conditions of the 1532 fire, atmospheric carbon could have been incorporated into the cellulose fibres. The principle of this is something like this: Cellulose molecules have these chemical groups, called hydroxyl groups (or alcohol groups). Under the conditions of the 1532 fire [assuming we know what these conditions were], silver would act as a catalyst (speed up the process) to take carbon dioxide and carbon monoxide from the air and convert the alcohol groups into groups called carboxyl groups. That means that the carbon from the air would then become part of the fabric. This is *theoretically* possible. However, again, the way it is presented raises a number of questions. Firstly, it could contradict the work of Dr. Garza-Valdes. Dr. G states that he found a biopolymer covering the surface of the fibres and unless under the experimental fire conditions that polymer also behaves like cellulose, then I cannot see how the CO or CO_2 or the silver catalyst could get to the cellulose. Secondly, assuming that it does, then this would only happen on the surface of the fibres. If the atmospheric carbon and oxygen incorporation were to happen deep in the fibre, then I would expect to see signs of significant fibre damage.

Finally, in another paper entitled "detection of alkylated cellulose derivatives in several archaeological linen textile samples by capillary electrophoresis/mass spectroscopy", (again, unless I have misunderstood) Dr. K appears to have shot himself in the foot! He agues that he found cellulose derivatives, similar to the ones he created in the simulated fire conditions, to be already present in textile relics ranging from 1200(ish) B.C. Egyptian, to 1500(ish) A.D. Russian. The ones which I found to match his simulated fire-induced derivative most closely were 1500(ish)A.D. Middle Russian relic, 900(ish) A.D. Northern Greek Relic, and 1300(ish) A.D. Polish Relic.

As for the reasons for these transformations, he states that "...we could note at least two possibilities. First, it is logical to assume that the cellulose alkylation that we have found in our work is a result of some unknown (lost, 'archaic') technological process for textile manufacturing... Second, it should not be excluded that the cellulose alkylation process is a result of the microbial contribution to the chemical modification of textiles."

So, what do we have here? If the material of the Shroud is found to have been modified in the way that was described in the simulated fire experiments, he could argue from his own work that such modification was there in the first place and was a result of some archaic process or microbial processes. In the latter case, we are back to the problem of Dr. G's work regarding the food that these microbes would need and where and when they would have got them. Maybe, it could be argued that the "lost/archaic" process was performed many centuries after the time of manufacture of the Shroud, say in the 14th century, in order to preserve it. Because a lot of bugs like to eat cellulose, but if it is modified, they can't.

In all of these cases, the heat, chemical and microbial modifications, the change would have to he on the surface of the fibres only, because, if it were deep, you would be able to see clear signs of fibre deterioration. If the changes are on the surface, then as I said with Dr. G's theory, the incorporated carbon would have had to come from well to this side of the 14th century, so that, combined with the original first century carbon (which would form the bulk of it), it may give a 14th century dating. In my humble opinion, all of these processes seem fairly unlikely to shift a carbon dating result by 14 centuries. In other words I tend to agree with the opinion of Dr. Damon et. al. as reported on page 11 of issue 41 of the BSTS newsletter. On the other hand, I *do* think that it can be argued that the sampling technique for the dating was inappropriate.

Dr. K also proposes two other possible mechanisms for an erroneous carbon dating result. He suggests that there may be variation in the C-14 content of contemporary flax fibres. In the light of evidence mentioned earlier, it is just possible that this could happen. However, this is a hypothesis which would need to be rigorously tested. If there were enrichment of C-14 in contemporary flax fibre, then carbon dating should date these samples to some time in the future, hopefully to about 3500 A.D.!

Lastly, Dr. K. has suggested that variations in solar radiation and geographic location would result in erroneous carbon dating results. This relates to the most basic assumption of radiocarbon dating that I referred to earlier. If we cannot assume that the carbon 14 levels are constant, then we should throw away all carbon dating data until we know more about the variables. But I suspect that there are good grounds for assuming that atmospheric C-14 levels are constant. Perhaps someone would like to challenge a carbon dating expert about the basis on which they assume that the levels are constant.

In Summary,

Regarding Dr. K's work, my first impression is that, as possible theories, he may be right on all counts, however, he is proposing too many mechanisms all of which appear to be contesting radiocarbon dating of "old textiles". [curious!]

Given the number of possible factors that he has proposed, it is curious that he should be able to account for one factor; the fire of 1532, and get to the date he wants? So, what about all of the other factors that he has proposed?

I feel that a scientist must be a public relations expert and be able to "demonstrate" that his interests are purely scientific. And that his findings just happen to support or not support a particular hypothesis (or claim) rather than being seen to be actively seeking to support or refute that claim. Otherwise, peers become suspicious of one's motives and begin to take one's experimental design to pieces. And as I indicated earlier, this is not difficult as no experimental design can ever be *perfect*.

Finally, I will conclude in the same vein that I began by saying that the scientific community is composed from and is representative of the general population, and as such is subject to the same hierarchy of motivational factors (that proposed by Maslow, for example, if you happen to be a maslowian). Consequently, obtaining respect and confidence amongst the scientific community has a bearing on the manner in which one's experiments are received. [For those scientists who wish to contest the possibility of subjective assessment, I refer you to the current internal political discussions on anonymous peer reviews!].

I said in my introduction that I wish to present you with an expose of scientific thinking with particular reference to its limitations, so that you will be in a better position to judge the scientific evidence for yourselves. I hope that what I have presented to you, this evening, will have gone some way towards achieving that objective.

I will close with a quotation of Albrecht Dürer, with which Sir Karl Popper ended his lecture entitled "Towards an evolutionary theory of knowledge", in 1990.: "But shall let the little that I have learnt go forth into the day in order that someone better than I may guess the truth, and in his work may prove and rebuke my error. At this, I shall rejoice that I was yet the means whereby this truth has come to light." Thank you.