

SPINACH, IRON and POPEYE:

Ironic lessons from biochemistry and history on the importance of healthy eating, healthy scepticism and adequate citation

By Dr Mike Sutton *[♣]

Student: “Why does Popeye eat spinach?”

Professor: “For iron.”

Student: “Show me the evidence.”

Abstract

To inform knowledge in research methods and dissemination ethics for the natural and social sciences, this article reinforces the importance of citation to support all assertions of fact. New findings are presented for the history of biochemistry, nutrition, psychology, medicine, and the social sciences. Bio-chemistry papers and scientific news reports from the 1930's seriously undermine a long standing truism that in the 1920s and 30s, bio-chemists, nutrition experts, public health policy makers, and E. Segar the creator of the newspaper comic strip Popeye were misled either by a decimal place error in 19th Century published research, or else by erroneous interpretation of 19th Century scientific findings, to exaggerate the iron content of spinach tenfold. Further, the failure to study original sources is evidenced in a multitude of completely erroneous publications claiming that these apocryphal errors caused Segar to choose spinach for Popeye's super human strength. In fact, Segar chose and promoted spinach for its vitamin A content alone.

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[♣] This article is dedicated to undergraduate and post graduate students everywhere, but is aimed equally at their tutors and professors.

Foreword: The IJC Primary Research Papers Series

The Primary Research Paper series in the Internet Journal of Criminology (IJC) was created with two main aims (1) for criminologists as a much needed outlet for disseminating their research findings from completed small-scale studies; or else (2) to facilitate the publication of early or incidental findings from larger on-going projects.

The publication of the article seeks to exploit the second of these aims.

Introduction

So that knowledge may facilitate progress, The Royal Society encourages healthy scepticism and promotes the scientific method to overcome unfounded beliefs. For the past 350 years the healthy sceptical motto of the Royal Society: *Nullius in verba* – ‘on the word of no one’ - or ‘take nobody's word for it’ has served many great scientists (Sample 2009).

Lewis Carroll’s *The Hunting of the Snark* (Carroll 1876) reflects the underlying intention of *Nullius in verba* where the Bellman says:

*“Just the place for a Snark! I have said it twice:
That alone should encourage the crew.
Just the place for a Snark! I have said it thrice:
What I tell you three times is true.”*

The joke in Carroll’s surreal poem is what Skrabanek and McCormick (1992) call the Bellman’s Fallacy, which explains how complete codswallop becomes accepted by those who should first check the research behind assertions of fact but don’t.

Religion provides a good example. There is no scientific law which says the more frequently a belief is voiced, or the more people that believe it, the more likely it is to be true or become true. Yet many academics, despite knowing that they should read original sources instead take short-cuts by ‘religiously’ accepting another author’s word for it. In this way, completely unfounded accounts gather citations and over time are elevated from humble beginnings as shamelessly fabricated codswallop to universally accepted knowledge.

Proper universities educate students on the importance of including correct academic references to support assertions in their written work. Furthermore, students are encouraged to read original published materials rather than merely recycling second-hand accounts of other authors. Some students latch on. But there are always a few who never do and so fail to thrive.

This article provides a salutary lesson by showing exactly what can happen when authors fail to reference their assertions and neglect to study original published materials. As you will see, it is better to be on the outside looking in and laughing at the published lies and factual errors of others than to be stuck forever on the inside of a story such as this.

Here is the story, from the beginning.

Fact checking a truism

At their core, many similar versions of a truism insist that biochemists, nutrition experts and E. Segar, the creator of Popeye, were misled in the 1920's and 30's by a misplaced decimal point in nineteenth century calculations of the amount of iron in spinach; or else by a misunderstanding of the meaning of nineteenth century findings of the percentage iron content of dried rather than fresh spinach. Depending on which source is read or heard, the truism is that either one of these mistakes acted alone or else together in a combination of forces to influence the comic strip writer Segar and/or nutrition experts and the general public in the late 1920's to overestimate tenfold, and therefore erroneously promote the nutritional importance of spinach over other foods, leading to an increase of over 30 per cent in its consumption during the 1920s and 30s.

This story is re-told many times in various books, articles, Websites and blogs.

My own involvement in this *Spinach Popeye Iron Decimal Error Story* (SPIDES) began when I told it, at Manchester University, to an audience of academics, criminal justice professionals and civil servants during my introduction to an academic paper on the impact of bad data on policy making (Sutton and Tseloni 2009). The precise version of SPIDES that I told was taken for the most part from "Spinach - The Truth" (BBC 2006):

"So what about Popeye, then? During the 1930s Popeye, probably the world's most famous consumer of spinach, was indeed credited with a 33% increase in the consumption of spinach in the USA. These days the Popeye brand of spinach is one of the market leaders.

The mythical strength-giving properties of spinach are, however, mostly credited to a simple mistake concerning the iron content of the vegetable. In 1870, Dr E von Wolf published figures which were accepted until the 1930s, when they were rechecked. This revealed that a decimal point had been placed wrongly and that the real figure was only one tenth of Dr von Wolf's claim."

The SPIDES story was well received as a humorous and therefore memorable example of the potentially huge impact of data errors on policy and public behaviour. And so I set out the very next day to find the original sources behind it to use in the references section of an academic article I planned to write on the consequences of bad data on policy making.

To support the assertions made in the SPIDES, I knew that I needed answers to the following four questions:

(1) Who is von Wolff¹ and where are his erroneous findings recorded? And where exactly is the evidence that any other scientists, such as von Bunge, and others up

¹ Wolff is frequently misspelt by those writing about the SPIDES as Wolf or Wolfe.

until the mid 1930s misplaced a decimal point in their presentation of findings regarding the iron content of spinach?

(2) Who were the 1930s chemists who discovered the decimal place error and where are their findings recorded?

(3) Since a correlation is no proof of causation, evidence is required to demonstrate that Popeye's creator Segar was indeed misled by erroneous science about iron in his choice of spinach for Popeye. And finally;

(4) where is the evidence to support the claim that Popeye was alone responsible for increasing US spinach consumption by 33 per cent – and that spinach consumption had indeed increased in this way in the USA between the late 1920's and early 1940s?

I expected to find my answers within about 30 minutes of fact checking online.

To begin, I opened the link to the search engine Google and found quite an amusing coincidence. The Google doodle for the day was of Popeye himself. Tuesday 8th December 2009 – the day after my presentation in Manchester - was the 115th anniversary of the birth of the creator of Popeye: E.C Segar.



Fig 1.

Clicking the Google doodle itself (Fig.1) led me, in turn, to open the Guardian newspaper's article (Gabbatt 2009) on the very subject of the SPIDES.

Gabbatt (2009) writes:

“Spinach is the source of Popeye's muscular prowess – upon eating it, his biceps immediately swell to three times their normal size. Segar² chose the vegetable due to an 1870 German study which claimed it contained the same amount of iron as red meat.”

Just like the BBC, Gabbatt (2009) of The Guardian provides no references to support his assertions, but does provide clickable links to a site run by Indiana University

² The creator of Popeye: Elzie Crysler Segar

called Sound Medicine (Sound Medicine 2004). Sound Medicine includes what turned out to be a typical re telling of the SPIDES:

“You remember the cartoon character, Popeye, who eats a can of spinach when he wants to develop some quick muscles.

Popeye's creators chose spinach -- instead of, say, brussels sprouts or broccoli -- because of an 1870 German study that claimed spinach contained about as much iron as there is in red meat!

In reality, this was nothing more than an accounting error. The scientists put the decimal point in the wrong place!

The iron content of spinach is actually one-tenth of what was reported. The mistake was corrected in 1937. It was too late for Popeye, though. He'd already been getting strong on spinach for almost 10 years!

Spinach does contain iron, but no more than other leafy vegetables.”

Actually, in my opinion, whoever wrote that for Indiana University should be reassigned to creative writing. Spinach does contain more iron than red meat. Tables from the excellent nutrient database of the US Department of Agriculture (2009) state that a 180g serving of boiled spinach contains 6.43 mg of iron, whereas one 170g ground hamburger patty contains just 4.42 mg of iron. What this University of Indiana website does not explain, however, is that only a fraction of the iron contained in spinach is “available” as a dietary source, a fact that is explained later in this article.³

Unfortunately for anyone fact checking the SPIDES for referenced sources, the Sound Medicine Website fails to provide any.

At this point my academic alarm bells were ringing. I switched to Google Scholar.

Entering the three words: “spinach Popeye decimal” immediately led to a more promising looking article from the prestigious British Medical Journal entitled “Fake” (Hamblin 1981). In that article Hamblin writes:

“A statue of Popeye in Crystal City, Texas, commemorates the fact that single-handedly he raised the consumption of Spinach by 33%. America was “strong to the finish ‘cos they ate their spinach” and duly defeated the Hun. Unfortunately the propaganda was fraudulent; German chemists reinvestigating the iron content of Spinach had shown in the 1930s that the original workers had put the decimal point in the wrong place and made a tenfold overestimate of its value. Spinach is no better for you than cabbage, Brussels sprouts, or broccoli. For a better source of iron Popeye would have been better off chewing the cans.”

³ Along with a hypothesis as to why that discovery in the 1930's is important to understanding the origin of the SPIDES.

While not mentioning the work of the 19th century German scientist von Wolff, Hamblin's (1981) British Medical Journal article reveals the essential components of the same SPIDES. He mentions that the Popeye character raised spinach consumption and that there was an early decimal place error in the iron content of spinach that led others to recommend the consumption of spinach due to an erroneous belief at to its high iron content.

Hamblin informs us that German chemists discovered the error in the 1930's and seemingly infers that spinach consumption played a propaganda role in WWII.

Hamblin is noted on Wikipedia for making the spinach decimal place error known to the public (Wikipedia 2009):

“He publicized the fact that, contrary to popular belief, spinach contains no more iron than lettuce, while pink succulent lobster contains none at all; like all invertebrates its respiratory pigment is based on copper rather than iron.”

Wikipedia is an unreliable source— often written and re-written by non-experts, sometimes mischievously (Spring 2000). It should never be cited as evidence of a fact. However it does have something telling to say about Hamblin, which is worthy of further investigation (Wikipedia Popeye):

“Early references to spinach in the Fleischer cartoons and subsequently in further stories of Popeye are attributed to the publication in 1870 of a study by Dr. E von Wolf which, because of a misprint, attributed to spinach ten times its actual iron content. The error was discovered in 1937 but not widely publicized until T.J Hamblin wrote about it in the [British Medical Journal](#) in 1981.”

As fact checking researchers, the questions we should be asking ourselves here are these: why was the decimal error story not widely known before Hamblin wrote about it – if indeed it is true that it was not widely known before Hamblin's article? And if it is true that Hamblin is famous for making the “truth” about the decimal error widely known, what then is the secret source of Hamblin's knowledge about the decimal error? Note also how the Wikipedia entry names Wolff, but misspells his name, and attributes the decimal error, which Hamblin supposedly first brings to the attention of the wider world, to him. Hamblin never mentioned Wolff at all. The Wikipedia entry, at least at the time of writing, provides no references to support this assertion – other than the BBC (2006) website we examined above, which provides no references of its own.

And so the soup thickens.

A multitude of self proclaimed “expert” websites re tell the SPIDES along the same lines as The Guardian, Hamblin, Wikipedia and the BBC. Some writers provide references to their source of the story, but the furthest back they go is Hamblin's (1981) article.

After several days of searching for facts, this exercise took on the bitter lonely-loser flavour of lost time chasing. So much valuable research time was spent on what appeared to be a futile exercise that I became, like a loss chasing gambler (Parke and

Griffiths 2004), determined to keep spending more until my losses were recuperated. I now needed to get to the bottom of the SPIDES for the sake of public knowledge. I turned to the Pub Med database and Google Scholar and began studying biochemistry papers and books on the history of nutrition.

Be warned: Dedicated research can take on the form of obsessive behaviour.

After two weeks of doggedly searching for and reading academic biochemistry and nutrition journals dating back to the 1920s, and books, for the source of the SPIDES I was no closer to discovering the truth. But I was becoming an expert on spinach.

Unable to find answers to any of my four questions, I sent a personal email to Hamblin, telling him about my fact checking mission and asking if he could possibly provide the original sources of the SPIDES that he mentioned in his 1981 article.

Hamblin replied by email almost immediately. He wrote that he has been asked for this before and that he honestly cannot remember. He said that back in 1981 he had been asked to write a humorous piece by the then editor of the British Medical Journal (BMJ) for its Christmas edition and that he had been asked not to provide references. This is rather an odd account since Hamblin's (1981) article does in fact contain 13 references to sources, none of which, however, cite the source of the decimal error or 1930's Germans in the SPIDES. Hamblin rounded off his email with the assurance that he was sure that he had not made it up.

Undeterred, I continued fact checking the SPIDES in my spare time and after some three weeks of late night work began to make some inroads. Firstly, I found that the story is being recycled all over the Internet. I have made no attempt to count the number of web sites that recycle it, but there are an awful lot of them, as you can see for yourself.

The Perpetuation of SPIDES on the Web

The SPIDES is re told as fact on so many websites that only a tiny representation of them can sensibly be cited in this article. It must be possible to enumerate the number of writers perpetuating the SPIDES and to cite them all and archive them for the future so that others may check the facts presented here for themselves, but as any net savvy search on Google will reveal there are so many publications on this topic that such a task is way beyond the scope of an unfunded fact checking exercise such as this.

Try typing Spinach Popeye Iron Error into Google to see how widespread and varied the SPIDES is.

Those promoting alternative medicine (e.g. Carla 2009) herbal remedies (e.g. Nutrasource 2009) and healthy lifestyles (e.g. Health and Wellbeing 2006) particularly love the SPIDES. In haematology there is Hamblin (1981), in chemistry Coultate (2009). And in medicine: Sound Medicine (2004); Carroll and Vreeman (2009); Steel (1996) and Larsson (1995) to name but a few.

My early experiences were representative of my later ones, in that authors writing on the subject merely reference the work of writers on another website, sometimes adding their own additional variation to the SPIDES and the trail of the story never goes back any further than Hamblin's (1981) article (see e.g.: Crook).

Gate's (2010) recycled story is typical:

"Despite a popular misconception, spinach has only slightly more iron than most other vegetables.

The mega-iron myth first began in 1870 when Dr. E. von Wolf misplaced a decimal point in his publication which led to an iron content figure that was ten times too high. Although investigated in 1937 by the Germans, the rumor remained strong for decades (thanks to a pipe-smoking sailor man)."

Large supermarket chains are not afraid to accept the SPIDES as accurate (Waitrose 2005). Such is the power of the SPIDES over healthy scepticism that Anaesthetics News – the Newsletter of the Association of Anaesthetists for Great Britain and Ireland (Rowlands 2005) - cites the Waitrose reference above as the source of their own SPIDES - as though that confirms its provenance as properly conducted research. Even rocket science professors cannot, it seems, resist it (Walter 2004).

Other more typical examples include Woodward (2000), a Senior Lecturer in biochemistry at the University of Tasmania who writes:

"I do recall reading years ago in a textbook - sorry, I can't recall which one - that the first Fe analyses published for spinach in the US in about 1920 suffered a misprint in the journal that published them, and appeared in the journal with the decimal point misplaced (effectively multiplying the value by 100). While the error was corrected in the next issue, it was stated that the extensive media coverage of this incorrect value inspired the author of the Popeye comic strip to have Popeye down a can of spinach whenever a crisis arose!"

Woodward is far from alone in academic company perpetuating the SPIDES in one form or another. Other very typical examples, among many more, are (Jaun 2006; Eswaran 2009; Emsley 2008).⁴

Even charitable bodies have jumped onto the unsubstantiated story wagon with factual abandon (World Hunger Relief 2008); along with websites offering to miraculously increase you science IQ (Skorucak 2010), whatever that means.

Myth busting websites love the SPIDES story and reference Hamblin's paper as the source of their knowledge of the decimal place error that misled everyone. A typical example is De-Fact-O (2008).

⁴ Emsley is typical of many "experts" in not checking original sources and so implying that Popeye should be associated with spinach for its iron content. This point is explained in more detail later in this article.

Some writers claim that if it was not the decimal point error of an elusive 19th century chemist often named as either von Wolff or von Bunge - then it was an error made by others in their interpretation of the more concentrated mg per 100gm dry – as opposed to fresh weight – spinach that led to the tenfold exaggeration of its iron content and subsequent increased promotion and consumption. A typical example of such writing is evidenced in the recent work of Coultate (2009: p446):

“Although spinach is one of the vegetables at the upper end of the range of iron content (~ 4mg per 100g) sadly there is no scientific basis for Popeye’s enthusiasm for it (v)”

In a footnote Coultate (2009 p.446: v.) goes on to explain:

“There are at least two versions of how this error arose. One suggests that in 1890 a German scientist, Gustav von Bunge, found the iron content of spinach to be 35mg per 100g, but it was overlooked that he had analysed powdered dried spinach, and this figure came to be associated in error with the fresh vegetable. An alternative possibility is that some 20 years earlier another scientist, Dr E von Wolf, had performed a similar analysis – but had misplaced the decimal point in the result⁵. Wherever lies the truth, the error was not picked up until 1937 and the myth has managed to survive the subsequent 70 years.”

Coultate’s (2009) book is published by the highly esteemed Royal Society of Chemistry in Cambridge, which is the largest organisation in Europe for advancing the chemical sciences. Coultate, however, makes no attempt to fact check or reference the source of the SPIDES. You have to wonder what he and his editors were thinking.

At least since 1981⁶, literally hundreds of expert scholars in various diverse fields have published materials that treat the SPIDES as unquestionable and yet have apparently not fact checked the actual origin of the story, because they provide no references to support it.

Weigman (2005) in her report aptly named “The Consequences of Errors” writes:

“...when models or dogmas are established on the basis of erroneous science, they are all the more difficult to eliminate.” And yet, Weigman herself, typical of so many commenter’s on this subject, ironically falls into the painful trap of accepting the veracity of the SPIDES and expecting others to do likewise, because she provides no validating references for the following statement (Weigman 2005):

“The comic figure Popeye convinced kids to eat spinach by attributing his superior strength to the leafy greens, despite its iron content having been miscalculated by a factor of 10 at the end of the nineteenth century. The error was detected in the 1930’s,

⁵ Later in this paper you will see that my research revealed that Sherman et al (1934) confusingly presented very high iron levels for what appears to be fresh spinach, but made no reference to either Wolff or Bunge. Two years later two of the authors of that 1934 paper rather foggily corrected the confusion (Kohler et al 1936).

⁶ And possibly before that date. More research is needed to be more confident of the exact origin of the SPIDES.

but spinach consumption was encouraged after World War II whenever possible, and still is today.”

My research in biochemistry and nutrition led me to study what is known about the iron content of spinach.

Iron levels for *fresh* spinach are around 2.75mg per 100gm (USDA 2009). Once *dried*, however, spinach contains substantially more mg of iron per 100gm, just as dried herbs contain far more concentrated flavour by weight and volume than when fresh.

Scientists in Pakistan recently found the figure for dry spinach to be 44.6 mg of iron per 100gm (Rewashdeh et al 2009), which corresponds reasonably well with most measures of the iron content of dried spinach, including that of 44.8 mg iron per 100gm dried spinach found by Jackson (1938) and the more recent finding of some 34 mg of iron per 100g dried spinach by Oladele and Obarisaide (2009), but less well with the unusually lower figure of a mere 20.7 mg of iron per 100gm of dried spinach found by Ruegamer et al in 1946.

McKillop (1916) reproduces one of von Bunge’ nutrition tables (Fig 2)⁷. As can be seen in Fig 2, spinach tops Bunge’s list of foodstuffs. This is because at that time scientists did not know about “available iron”⁸ and had no knowledge about the effect of oxalic acids on iron availability in foodstuffs. While “other green vegetables” are placed at the top of the list alongside spinach, they are somewhat bracketed off to secondary status. The ranking of this table does not say that spinach is any higher in iron than any other green vegetables⁹, but it is easy to see why people might have thought that was the case.

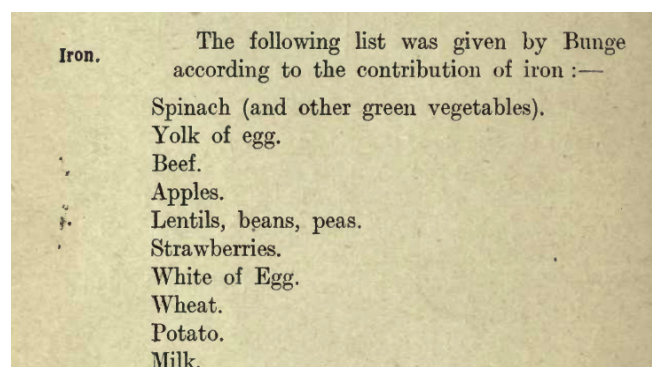


Fig 2.

Bunge appears to have advocated a diet including spinach to prevent rather than treat anemia. We are told that Bunge (1902) (cited in Poskitt 2003) was a healthy skeptic who, true to the spirit of this article, asked “where is the evidence” that any food is rich enough in to treat iron deficiency? McCay (1953) writes that Bunge also

⁷ Since this is a replication of Bunge’s table by another author we cannot be certain that it is accurate without reading Bunge’s original work. But as a 1916 publication on nutrition, it is valuable in its own right in that it places Spinach at the top of the list and gives it prominence over other greens.

⁸ See Bowering, Macpherson, Sanchez and Irwin (1976)

⁹ McCay (1953) observes that von Bunge did make a notable error in publishing the iron content of haemoglobin, which was corrected by one of his own students.

recommended that as soon as they had eight teeth infants be fed a teaspoonful of spinach in order to prevent anaemia.

The biochemistry and nutrition journals examined for this article make not one mention of Segar and Popeye. Similarly, not a single mention is made of Wolff's alleged decimal place gaff, nor of chemist Gustav von Bunge's figure for the iron content of dried spinach that others (e.g. Coultate 2009) claim to be the source of the story.

Thankfully, the author is not completely alone in finding the absence of such evidence most peculiar. The Straight Dope¹⁰ Website (see: Tammi Terrell 2007) contains this useful lead (with references) from what appears to be the only other SPIDES sceptic in the world:

“Last summer, precisely because of that Wikipedia page and its mention of Hamblin's article, I did some preliminary research into the original works of Emil Theodor von Wolff (1818-1896), whose Aschen-analysen von Landwirthschaftlichen Producten, Fabrik-abfällen und Wildwachsenden Pflanzen (2 volumes; Berlin: Wiegandt & Hempel; 1871 and 1880) provides chemical analyses of burnt plant materials (for the determination of, for example, iron content). Gustav von Bunge (1844-1920) is also fingered as the culprit who misplaced a decimal point in the estimation of iron in spinach; consequently I looked at an English translation (1902) of his Lehrbücher über die Pathologische und Physiologische Chemie.

As for Hamblin's claim that "the original workers had put the decimal point in the wrong place and made a tenfold overestimate of its value," I have to say that I've yet to find any evidence of this kind of simple mathematical goof in the works of those who are usually given credit for the original work.”

Tammi Terrell¹¹ (2007) rounds off her comments:

“In the end, I think there is more to find out about the historical roots of a misconception about spinach as a great source of iron, but we're not going to find it in Hamblin's article or in Wikipedia.”

Where is there then any published evidence then of the impact of errors made in the recording of iron levels in spinach?

My biochemistry research unearthed a number of articles from ground-breaking researchers at the University of Wisconsin. In one particularly important article, three of the university's highly esteemed chemists strangely appear to attribute fresh spinach with an iron content normally associated with dried spinach. Table I in Sherman, Elvehjem and Hart (1934) appears to claim that fresh spinach contains 53

¹⁰ Note: anonymous websites such as this can be very useful in providing leads but they should not be relied upon as references to support facts. Treat them with extreme caution and healthy scepticism as you would Wikipedia.

¹¹ Presumably an anonymous contributor to the Website. Tammi Terrel Also the name of a soul singer who famously sang “Ain't Nothing Like the Real Thing.”

mg of iron per 100grams¹² (published as 0.53 mg per gm.), when, to repeat a point already made above, the real figure is in the region of 2.27mg per 100gm.¹³ And most tellingly that article makes no reference to either von Wolff or von Bunge.¹⁴ This iron content confusion is all American and has nothing to do with Victorian Germanic scientists. Whether or not Sherman et al (1934) were clear in their own minds that they were presenting the iron content of dried rather than fresh spinach is not known. What we can say is that they failed to do so clearly and so published a paper that could have easily been misinterpreted by others to think that spinach contains 20 times more iron than it actually does.¹⁵

Most crucially, the next year, on 17th August 1935 the Society for Science and the Public published in their newsletter (The Science News-Letter 1935) a feature on these University of Wisconsin scientists, with the title: “Spinach Over-Rated As Source of Iron.”

The article includes the following revelation:

“Science is coming to the defense of the youngster who refuses to eat his spinach.

Mother, it seems, is only partly right when she pleads with junior to “Eat your spinach-it’s good for you.”

It’s good for him, but not nearly as good as its cracked up to be. It just can’t be spinach that enables Popeye the Sailor to perform those red blooded feats in the movies. For spinach contains iron, but-

New studies at the University of Wisconsin, carried on in those agricultural chemistry laboratories which have already made countless contributions to the knowledge of vitamins and minerals, show that 25 per cent of the iron in spinach is “available”, as scientists put it. That is, only one-quarter of it is in a form that is usable by the body. Other vegetables are no better than spinach in this respect.”

A year later, Kohler, Elvehjem and Hart (1936) state that fresh spinach is best used to determine its iron levels. However, they give no figure for the iron content of fresh spinach, only for dried spinach, which now is said to be 35.2 mg of iron per 100gm.¹⁶ Again this university of Wisconsin paper is also very unclear. Because Table 1 in the paper presents the figure for dried spinach –labelled as ‘dry material’ in the vertical

¹² P385: “The finely ground fresh biological material was weighed into a 100cc beaker and boiled for 10 minutes with 15cc of 5n hydrochloric acid.”

¹³ Sherman et al (1934) give the same figure in Table II as they do in Table I and it is only in their Table III that they label spinach as dry. Note just how close this referenced fact is to Coultate’s unreferenced story – above.

¹⁴ Clearly these Wisconsin chemists knew to distinguish between fresh and dry spinach. In 1928 Elvehjem co-authored a paper with Peterson that records dried spinach containing a surprisingly low 0.00660 per cent iron: <http://www.jbc.org/content/78/1/215.full.pdf>

¹⁵ I would like to thank my colleague Paul Paddock, Principle Lecturer in Occupational Health at Nottingham Trent University, for double-checking these tables and refining my conclusions regarding them.

¹⁶ Note that Coultate (2009), see above, suggests that the origin of the SPIDES may be from a misunderstanding based on 19th century research that fresh spinach contains 35 mg of iron per 100grams.

column yet labelled fresh in the horizontal column; once again leaving room for misinterpretation that could lead to exaggerated claims for the iron content of spinach.

In making the connection between Popeye and Spinach for its iron rather than vitamin content, the Science News Letter (1935) article could very well be an important part of complex puzzle that is the origin of the SPIDES. At least we know now that Popeye's spinach was being associated with iron as far back as 1935. However, the article does refer to: "...those red blooded feats in the movies." Perhaps the animated 'movie' Popeye cartoons, which were not penned by Segar, advocate spinach for its iron content? There's only one way to find out of course: more research.

Most notably relevant perhaps it is the fact that this 1935 news item made no mention of the much SPIDES-maligned Von Bunge or of Wolff as being at the root of any misconceptions regarding the iron levels in spinach – whether they be levels for available or unavailable iron. In the absence of evidence of a decimal error in either von Wolff's or Bunge's calculations, or evidence that the work of either was misunderstood by 1930's American biochemists, the preliminary evidence presented here suggests that the source of the SPIDES does not lie with the published work of either Wolff or Bunge. The decimal error story seems to have its origins in that BMJ article (Hamblin 1981).

So is the Spinach Popeye Iron Decimal Error Story (SPIDES) a Myth?

My own painstaking analysis of the original Popeye newsprint comic strip cartoons¹⁷ reveals quite clearly that Segar chose spinach as the source of Popeye's power because of its high vitamin A content (see: Fig. 3).



Fig. 3. Segar July 3rd 1932

This cartoon (Fig 3) shows Popeye explaining for the very first time why he eats spinach. Of the hundreds of Popeye cartoons studied to date for this article¹⁸ not one

¹⁷ Facilitated greatly by the convenience of bound volumes, which faithfully replicate the complete Thimble Theatre comic strip cartons, featuring Popeye, between 1928 and 1935 (Segar: 2006; 2007; 2008; 2009).

¹⁸ Initial, primary research, content analysis conducted of Volume 1 Sept 1928 – Feb 31 (Segar 2006) and Volume 3 June 1932 – Nov 1933 (Segar 2008).

makes even the slightest association between spinach and iron. This one cartoon, which appeared in print on July 3rd 1932,¹⁹ exposes a major part of the SPIDES as an absolute load of old codswallop.

In the 1920's, scientists found that they could significantly improve children's nutrition with vitamin A derived from spinach (see: Willimott and Wokes 1927). With the benefit of proper research, the fact that Segar's choice of spinach for Popeye in 1932 was due to its vitamin A content, and not iron, comes as no surprise.

There can be no doubt then that it was the vitamin A²⁰ content of spinach - not any exaggerated claims as to its iron content - that led Segar to choose these greens as the source of Popeye's superhuman powers. Had Hunter (1971) bothered to research the namesake of his Lancet article entitled: Why Popeye Took Spinach he would never have published a load of old codswallop in that most esteemed medical journal. Because Dr Hunter would have realised that Popeye's creator was Segar and not Max Fleisher and that spinach was never chosen for Popeye because of its iron content; and it was most certainly not magically chosen for its soon to be discovered folic acid content either (Hunter 1971: 10 and 11):

“When in the early 1930's Max Fliesher, the creator of Popeye, cast around for an instant restorative and vital energiser to assure his sailor hero's triumph over adversity and survival for next weeks thrilling episode, his choice almost inevitably fell on spinach. Americans began eating it in quantity from about 1920, when it was shown to contain body-building calcium and iron”

and:

“Evidence now forthcoming, if confirmed, by its effect on brain-amine metabolism, was the rapidly acting activating agent, and the reason why Popeye chose spinach.”

Note that Hunter's paper makes absolutely no mention of the now famous decimal error part of the SPIDES told by Hamblin ten years later (Hamblin 1981).

Proper library research reveals also that the huge US Commonwealth Fund nutrition programme did not at the time recommend spinach as a meat substitute but as a meat accompaniment. Lovett (2005) writes of an article published in the journal Hygeia, where another writer (Brown 1928) is cited for telling the parable of a teacher of the time describing the ideal nutritious meal as spinach, lamb chop, baked potato, brown bread, sponge cake, applesauce, and milk. Note: the inclusion of meat alongside spinach suggests that spinach was not promoted as a meat substitute at this time.

Contrary to certain renditions of the SPIDES then, Segar does not appear to have promoted spinach as a meat substitute at times of meat shortage and economic

¹⁹ The picture in Fig 2 is of a limited screen print (owned by the author) by the printer John Patrick Reynolds of Segar's original from July 3rd 1932. The colours in the screen print are slightly different from the original and a garden hoe is missing. Nevertheless, the text is identical to the original, which can be found reproduced on page 162 of Segar (2007). The author bought the picture in 2010 during the course of his research for this paper.

²⁰ Or at least what is now described as its retinol equivalent activity. Retinol is another name for vitamin A) see: <http://www.spinachwords.com/nutrients1.shtml>

depression in the USA. Rather, the available evidence from his comic strip cartoons reveals that Segar's aim was for parents to introduce vitamin rich greens into children's diets and to influence children's own nutrition choices. Segar would have known that the "eat your greens" message would not be easily received, because at the time he was trying to get the message across, greens were culturally embedded as cow food (see Lovett 2005, p 822.). This is no doubt why the woman depicted in Fig 3 asks if Popeye is a horse when she finds him eating raw spinach. Contemporary humour is used here in a society where agricultural matters were much closer to home than today.²¹

On 27 June 1933, almost one year after Segar had Popeye explain the vitamin benefits of Spinach, he runs a story line where mythical jay birds are 100 times better to eat than chicken. Vitamins are once again the reason. The birds are so good to eat because they contain all the vitamins in the alphabet (Segar 2008: 67). No mention is made of iron.

Segar made a consistent and determined effort to promote spinach as a nutritional choice for children. Here are just a few examples:

In July 1931 (see Segar 2007 p. 44) Popeye includes a special message, written in his trademark mangled English:

"Special letter to me children frens – Dear kids – the reasin why I yam so tough an' strong is on account of I has et spinach when I was young – An if you youngstirs wants to be helty like me ya got to eat yer weeds like yer maw sez – yers trulie Popeye.

In October 1931 Segar (2007 p123), has a child boycotting his own spinach diet by saying: *"I've told you ten times that I won't eat my spinach unless you get my pal Popeye out of jail."* While his mother frets: *"Mercy: mercy! The doctor says he must eat spinach."*

On 28th February 1932 (Segar (2007 p144) has Popeye pen an open letter to his adult cartoon readers in which writes in his illiterate hand:

"NOTICE TO MOTHERS OF CHIL'REN: Please tell yer youngstirs I said they should eat spinach and vegeables on account of I wants 'em to be stron an helty – I will be a personal fren of all chil'ren who eats what their maw says to eat – yers trulie Popeye."

On June 19th 1932 (Segar 2007: p160) Popeye kindly tells a young girl: *"Eat yer spinach now Mary Ann - Then ya won't need no blasted castor oil."*

And the comic strip of September 18 1932 included a print of \$1 Popeye play money that has Popeye saying: *".. An don't forget to eat yer spinach"*

²¹ The use of such imbedded humour by Segar in getting the public health message across to promote attitude and behaviour change is worthy of serious research based upon facts rather than spurious and misleading humour in otherwise respectable journals (e.g.: Hamblin 1981; Hintz 2001). Psychologists have been studying this for years. See Sutton et al (2007) for some useful examples.

One frame of a cartoon such as Fig. 3 can speak more than thirteen thousand words, which coincidentally is the length of this article. Fig 3 debunks once and for all the long standing truism that Segar first chose and subsequently promoted spinach as the source of Popeye's strength because of some kind of misunderstanding about its iron content.

All the evidence, then, from my own analysis of the original Popeye cartoons reveals that Segar appears to have been adding Popeye's voice to assist the Commonwealth Fund nutritional programmes during the childhood nutritional crises (Lovett 2005) of first half of the 20th century.

While the full-blown SPIDES then is an urban myth, the evidence presented in this Primary Research paper answers only questions 1 and 3 of my original four research questions. All the evidence suggests that, in the absence of references to prove otherwise, Hamblin (1981) invented the decimal error part of the SPIDES and invented therefore the mysterious German scientists who he tells us discovered the invented error.

Is von Wolff relevant to the SPIDES?

Regardless of whatever errors Wolff's work may or may not contain on the iron content of spinach,²² and whatever errors may or may not have been made by others interpreting the iron content of spinach reported by either von Wolff or von Bunge, these apocryphal errors have not been adequately referenced in the works of anyone mentioning them. This means that the claims are difficult to fact check without a painstaking study of everything written on the subject by Wolff and Bunge.

On the other hand, there is no escaping the fact that my research for this article reveals that highly influential American chemists in 1934 may have misled others to exaggerate almost twenty fold the iron content of fresh spinach (Sherman et al 1934).

Most tellingly, Sherman et al (1934) make no reference whatsoever to any other authors as the source of the figures they present for the iron content of spinach displayed in their tables.

Further, my research, which is adequately referenced, allows me to tentatively hypothesise, in answer to my Question 2, that the data presented so far supports a tentative hypothesis that it was in fact US scientists headed by Kohler²³ (Kohler et al in 1936) who were the first to "correct" an iron/spinach confusion that existed in 1934; not, as the SPIDES would have it, some unreferenced, unknown shadowy German scientists correcting the work of American chemists all writing erroneously about the iron levels of spinach up until 1937.

²² Once again research is needed before we can be more confident. A full English translation of Wolff's work relevant to this question would be most useful.

²³ Kohler was in fact not German but Pennsylvania Dutch, and originally from a community that practised Germanic farming traditions See: <http://books.nap.edu/html/biomems/ekohler.pdf>

Hoisted by their own petards: a most embarrassing double irony

It is often said that we are best at giving advice to others on issues where we need it most ourselves. Ironically, because the SPIDES is held up by many writers as true they cite it with absolute confidence as a genuine example of the importance of checking facts (e.g.: Maubossin, M. 2009²⁴; Knowles and Gonthier 2009).

For at least thirty years the SPIDES in whole or in part has been presented as a real example of perhaps the greatest typographical error in history that impacted upon both public health nutrition policy and infant and parental nutrition choices. Equally, it is held up as a true story by methodologists and others to stress the importance of checking original sources. Such has been the strangely enchanting power of the SPIDES that even the most strident skeptics, publishing papers on the importance of citation and healthy skepticism, believe on the basis of no cited evidence whatsoever that the “decimal error” part of the Spinach-Popeye-Decimal-Error-Story is a credible example of the need to be skeptical and read original sources. This typical ironic and embarrassing academic mistake is made, for example, in an article ominously entitled: “The dissemination of false data through inadequate citation” (Larsson 1995).

In his article Larsson (1955) is quite rightfully scathing of other writers who blindly cited a methodologically flawed paper, which found higher than expected birth defects among Polish dental workers. The coverage given that paper by those who had not actually read it, according to Larsson has further misinformed knowledge about the safety of amalgam fillings. Here, at length, is what Larsson (1995: 448) has to say on this important issue:

“Improper use of references is not only a matter of academic credibility or misconduct in medical research, but can also lead to serious consequences in health care. The accuracy of quotations and references in medical journals is a matter of concern... Misquotations that slightly misled the reader or seriously misrepresented the original were found in 12% of all references studied in six medical journals published during January 1984...”

It is discouraging to that, in many publications, the study is referred to without critical comment on the epidemiological methods. Even in papers expressing such critique, some authors nevertheless seem to accept without question the conclusions of the study...

When unfounded statements are repeated frequently they tend to be accepted: the difficulties in correcting such ‘accepted facts’ are well recognized. The myth from the 1930s that spinach is a rich source of iron was due to misleading information in the original publication: a malpositioned decimal point gave a 10-fold overestimate of iron content [29]. Once a paper with misleading information has been published, it is almost impossible to stop citation.”

²⁴ See also: <http://www.simoleonsense.com/attention-michael-mauboussins-latest-strategy-piece-see-for-yourself-the-importance-of-checking-claims/>

And (Larsson 1995: 449):

“Great efforts are made to prevent fraud and misconduct in biomedicine... A commission of the Danish Medical Research Council is dealing with the problem of ‘scientific misconduct’ and has included all types of ‘forgery or distortion of the scientific message or a false claim of the researchers’. ...In my opinion, the Polish study contains an erroneous interpretation of results and distortion of conclusions. Although I do not mean to infer that this was a deliberate error by the authors, the consequences are no less serious: false information has been disseminated through inadequate citation.”

How right Larsson (1995) is.

Unfortunately for Larsson however, the sole source of his number [29] reference, above, is Hamblin (1981). And Hamblin, as we know, never referenced the source of his decimal error story and says that he does not remember where he got it from.

What was Larsson thinking when he cited Hamblin without questioning the veracity of his story? Could Larsson believe, perhaps subconsciously, that any stories about the history of nutrition, public health and the use of media to effect infant and adult attitude changes, if they include the comic character Popeye do not need to be taken seriously and can be afforded inaccurate artistic license in order to get a laugh? Perhaps Hamblin fell under the same spell when it came to writing about Popeye – perhaps humour can greatly facilitate the planting and nurturing of prevailing lies?

Such incredible and embarrassing double irony as found in the Larsson (1995) case is not rare when it comes to the power of the SPIDES.

Many others who have perpetuated the *Spinach Popeye Iron Myth* have not actually read the relevant early biochemistry papers on the iron and vitamin content of spinach. And it is clear that they have not studied the original Popeye comic strips (e.g. Carroll and Vreeman, 2009).

Another example of double irony, can be found in the work of Weigman (2005) that we examined above. In her article on the consequences of errors, Weigman (2005) makes the mistake of blindly accepting and recycling the Spinach Popeye Iron Decimal Error Story (SPIDES). Worse, she falls deeper into her own trap when she goes on to lecture us: “In many cases, errors are unavoidable, but premature enthusiasm may forgo the need for critical evaluation.”

Weigman (2005) and Larsson (1995) are not the only ones hoisted by their own petards. Many “experts” advising us on the consequences of recycling errors in science have themselves blindly accepted and recycled the SPIDES - therefore failed to check the veracity of their own work. Yet another typically ironic example is provided by Gustavii (2008: 149) in a Cambridge University press book entitled: “How to write and illustrate a scientific paper”:

“Popeye, the beloved cartoon character, would probably never have been created had it not been for a misplaced decimal point. As you know, Popeye gets his strength

by eating spinach, assumed to be rich in iron. This misconception derives from a report indicating, due to a misplaced decimal point, that spinach has an iron content tenfold higher than its true value. An overlooked error seldom has such amusing consequences, however."

In fact it is Gustavii's (2008) failure to fact check his own example of the consequences of failing to fact check sources that has amusing consequences now.

I should imagine that such painful irony seldom has amusing consequences for those who fall into their own academic booby-traps.

To be more charitable to all the many esteemed authors blindly re-telling the SPIDES as fact without checking the facts for themselves, it is not rare for clever people to believe stupid things. In his excellent book *Bad Science*, Goldacre (2009: 253) explains why this is so:

"Communal reinforcement is the process by which a claim becomes a strong belief, through repeated assertion by members of a community. The process is independent of whether the claim has been properly researched, or is supported by empirical data significant enough to warrant belief by reasonable people."

This communal reinforcement, as we have seen in this article, can take the form of a full-blown SPIDES re-telling, which neatly fits Skrabanek and McCormick's (1992) *Bellman's Fallacy*. As part of this process, many writers on the subject of Popeye, iron or spinach make a more subtle contribution. Some do no more than ignorantly associate Popeye's choice of spinach with its nutritional iron value. These minor inferences in the wider literature might, however, subtly reinforce the full blown SPIDES. By associating Popeye's use of spinach for vitality as motivated from his creator's ignorance about its iron content, rather than a pro-choice made for its vitamin content, writers may possibly perpetuate the SPIDES. Langley (1995) provides a typical example:

"Popeye, "strong to the finish, 'cos he eats his spinach," and Jack Sprat, who would eat no fat (and his wife would eat no lean), seem to have inspired the Meat and Livestock Commission's campaign Meat Matters, which is aimed at consumers, health professionals, and journalists.

One of the eye catching national advertisements compares the dietary iron contained in a huge tower of raw spinach on one plate and a grilled steak on the other. A great photo opportunity, but not quite the "rational" approach boasted by the commission. Although steak ranks highly among meats in iron content, spinach is not the front runner among plant sources. Indeed, Popeye might have done better to take a spoonful of black molasses since, gram for gram, molasses, cashew nuts, soya beans, wholemeal bread, and even popadums provide considerably more, and better absorbed, iron than does spinach."

And, typical of many who perpetuate the SPIDES, Langley compounds the irony of her own factual obscuration when she writes:

"It would be unfortunate for the health of the nation if the facts were obscured by the "creative treatment" used in this campaign..."

How and why the urban myth SPIDES came about in the first place?

Clearly, Popeye's creator E.C. Segar has been for decades - unjustly it turns out - associated with errors made in the calculation of the iron content of spinach and later discoveries about the nutritional availability of its actual iron content. However, a full content analysis of Popeye comic strip cartoons that were drawn by other cartoonists after Segar's' early death in 1938 might reveal a spinach-iron-Popeye association. So too might a content analysis of all the animated cartoons, which ran for more than 60 years. The study of urban myths, academic fraud, disinformation, and propaganda would perhaps be well served by funded research of this kind into the SPIDES.

Whether or not the Popeye iron-spinach association is fair is another matter. And it is this question that is addressed next.

So why is Popeye associated with spinach in the SPIDES?

Popeye is seen as an *iron man* or calls himself one (Fig. 4). This "iron man" reference may perhaps have in part stimulated the SPIDES, or could have helped it along by association. But that seems rather improbable.



Segar: September 25 1931



Segar: December 2 1932

Fig. 4.

The first Popeye animations and others studied to date²⁵ make no mention of iron in spinach.

²⁵ Many are abhorrently racist of African Americans, Native Americans, Chinese and Japanese people.

Hamblin (1981) mentions war propaganda in his BMJ article and this may be a clue or just another red herring. Popeye cartoons were used in anti-German and virulently racist anti-Japanese propaganda campaigns. However, only a full content analysis of all Popeye animated cartoons would adequately determine their influence upon the long standing popular connection between Popeye, spinach and iron.

The iron content of spinach is no greater than other green vegetables such as cabbage and broccoli, and yet it has, in the past, been given star status as a rich source of iron. Why?

Jill Fullerton Smith, head of factual programming for BBC Scotland in her book (Fullerton Smith 2007) entitled: “The Truth about food,” makes no mention of Popeye but she does write that an increase in spinach consumption was caused by a data error that created a myth about its iron levels. Unfortunately she does not provide any further “facts” evidence or references to support this particular “truth” about food.

There is one very important lesson so far to be gained from this primary research paper for all scholars in all disciplines. Namely, if you do not seek out, read and cite the original sources of accepted wisdom then your academic reputation may be in peril²⁶; A lesson that applies equally to the next sub-section of this article.

Several academic articles are flawed in their explanations and historical knowledge of the role of Popeye in changing nutritional attitudes of children and parents. We examine one of these in detail next: *The Popeye Principle: Selling Child Health in the First Nutrition Crisis* (Lovett 2005).

The Popeye Principle: public policy lessons from the past

Lovett’s (2005) otherwise excellent article, on how various agencies and public health programs in the United States in the 1920’s created new social norms in terms of children’s beliefs, attitudes, and behaviour towards health and nutrition at the time of nutritional crisis, fails to mention Segar’s original newsprint Popeye stories of the 1920’s and 30s. And so Lovett (2005) never considers the likelihood that Popeye’s love of spinach, which dates back to 1931 with clear public health messages addressed to parents and children (see Segar 2007), may have played a minor – or perhaps even significant cultural role in the process of creating and embedding those norms, rather than, as Lovett believes, merely exploiting them when the first animated Popeye cartoons were released in cinemas from 1933 onwards. Lovett’s (2005) flawed, but otherwise excellent, academic article on Popeye and nutrition teaches us once again the importance of studying original source material.

In June 1931 Popeye revealed for the first time that eating spinach is the secret to his superhuman strength (Segar 2007) when an adversary says: “*You lick my best men – you break jail at will – you escape from a ton of rope – how are you able to do such things?*” Popeye replies: “*Tha’s easy. I eat spinach.*”

²⁶ The findings presented in this paper emerged during my initial forays fact-checking for a wider study into the impact of bad data, evaluation deceptions and unfounded assumptions on crime reduction and policing policy making.

And yet, apparently, never having studied the original newsprint comic strip source of her “Popeye Principle”²⁷, Lovett (2005: 805) writes only of the later animated cartoons played in cinemas:

“From his first films in 1933, Popeye the Sailor relied on spinach to allow him to settle scores ...Indeed, for decades, the feisty sailor’s reliance upon canned spinach was credited with increasing its consumption by a third during the Great Depression, making it at the time the third favorite food among children, after turkey and ice cream ...Popeye’s producers at Fleischer Studios did not invent the association between spinach and strength; they exploited a social norm instilled in the course of the malnutrition crisis. That such social norms regarding food and nutrition can have tremendous influence, especially on children, is what I call the Popeye Principle. This article does not concern the influence of such norms as much as the process by which they are created.”

In the very first celluloid animation²⁸, Popeye immediately explains through song that he is strong to the finish because he eats spinach <http://www.youtube.com/watch?v=HR0FJyutA-c>. However, to repeat the point already made, this first animated cartoon was not released until two years after Popeye announced for the first time in 1931 that it is spinach that makes him strong²⁹. Being part of the powerful William Randolph Hearst news empire, and having gained a huge following and lucrative syndication, Segar’s comic strip hero was already a national institution in the USA prior to the release of Popeye the Sailor in 1933 by Max Fleischer. This might at first appear to be a relatively trivial and pedantic point, nevertheless – particularly given the title of Lovett’s (2005) article – *The Popeye Principle* - its historical importance, if we are to learn accurately from our past in order to inform current and future nutritional crises³⁰, is key to a fuller understanding of the cultural impact of the histories of public health, education, philanthropy and advertising upon Popeye’s creator Segar (as teacher via culture), and in turn the extent of Segar’s own cultural impact (as both teacher, artist and advertiser), upon Fleischer Studios, Paramount Productions and the purported 33 percent increase in consumption of spinach that has been attributed to Popeye.

As Lovett (2005: 803) writes:

“The history of the malnutrition crisis demonstrates the importance of understanding the cultural and economic conditions surrounding childhood nutrition, the use and influence of nutritional norms, and the mutually reinforcing influences on children’s nutritional norms from their parents, peers, teachers, and culture.”

Unfortunately, belief in the SPIDES is so widespread that even “experts” writing in the International Journal of Obesity (Rosner 2007) repeat it and so demonstrate that they fail to grasp the importance of historical accuracy in understanding lessons from

²⁷ Because Lovett (2005) never mentions it in her paper.

²⁸ These can be viewed in the UK, by those in possession of a multi-regional player, on DVD from Warnervideo. See Popeye The Sailor Volume 1: 1933 – 1938. 60 Theatrical Shorts on 4 discs.

²⁹ The first animated Popeye cartoon was realised for public consumption on July 14th 1933 (Ultimate Disney 2007).

³⁰ Such as the current Western obesity crisis.

past nutritional campaigns – including the use of comic strips to influence nutrition choices.

Lovett (2005) explains how the height to weight ratio system that informed diagnosis of malnourished children in the US nutritional crisis of the 1920s and 30's was eventually found to be so inaccurate that it was replaced by individual medical assessment. This is particularly valuable information. Because in today's obesity crisis in the West (Skidmore, P. and Yarnell, J. 2004)³¹ it seems that *one size fits all* ratios are again being used to assess the masses.

As part of the current National Child Measurement Programme, parents in the UK are receiving letters through the post informing them that their children are overweight. This labelling of children and parents as nutritional deviants has caused such an outcry recently that Bournemouth and Poole NHS included the following statement on their Website (Bournemouth and Poole 2010)

“We are sorry about the concern that this letter may have caused some of our parents, and this was certainly not our intention - we have also had some positive feedback about this process and our approach. We will be looking at the language and the processes that we use, but our priority is about ensuring the ongoing good health of our children.”

The BBC (2010) highlighted the story of how the parents of one sporty girl, who was just 1% on the outside of the uniformly acceptable body mass index felt, stigmatised after receiving a computer generated letter from the National Health Service warning them of the dangers to their daughters health. Perhaps lessons can be learned from the past?

Criminologists concerned with the issue of increasing criminalisation and stigmatisation of the population for anti-social behaviour, white collar crime, environmental crime, motoring offences and expenses fraud could do a lot worse than keep an eye on developments in the area of *“fat crime”* (see: Templeton 2007; USA Today 2009).

Just how responsible was Popeye for the increase in spinach consumption in the USA?

Lovett (2005), citing Mack (1928), writes of that time in the USA:

“Where in 1915 so little spinach was raised for wholesale trade that it did not appear in shipping summaries, by 1928 there were 48,530 acres...”

Spinach, and other culturally alien greens, had been so promoted by the US Commonwealth Fund as necessary for children's nutrition, that in 1928 they were the subject of one of the best known cartoons in The New Yorker (New Yorker Cartoon) magazine. In the cartoon a young girl aged around seven or eight years is at the dinner table with her mother. *“It's broccoli, dear,”* says mother, and her daughter replies: *“I say it's spinach, and I say the hell with it.”*

³¹ See also: <http://qjmed.oxfordjournals.org/cgi/reprint/97/12/817> for evidence from the USA.

The fact that spinach consumption was on a steep upward trend between 1915 and 1928 makes all the more pertinent my Question 4 regarding the need for evidence that Popeye alone was responsible for a 33 percent increase in spinach consumption; particularly since Popeye never ate spinach until June of 1931 (See: Segar 2007 p 40). Was canned spinach perhaps promoted for its iron content at any time before or after Popeye started advocating it?

Incidentally, in the earlier newsprint cartoons, Popeye displays superhuman characteristics without recourse to any nutritional assistance. Popeye survives several bullet wounds on May 16th 1929 by stroking the three hairs on the head of *Bernice the good luck whiffle hen*. Later, in October 1930, Popeye relies solely upon a meal of beef to overcome mere bedridden weakness from a total of 25 bullet wounds. It was around this time, though a little earlier, on July 22nd 1929, that spinach first makes an entry into the Popeye comic strip, not as a foodstuff but as Miss Spinach, the landlady of the cad Mr Herringbone. All of these minor historical details aside, after that beef meal in 1930, Segar settled on spinach for Popeye in 1931 and his comic creation remained faithful to eating and promoting it thereafter.

The fact that Popeye was already doing his tough guy stuff well before he became a spinach user suggests that Segar may well have later made a decision to employ his creative work to support programmes promoting spinach consumption during the US nutritional crisis. I am not sure, therefore, how exactly it is possible to isolate the influence of Segar's Popeye from that of wider nutrition programmes on spinach consumption.

As a further note of caution, not wishing to start any bad science based harmful urban myths here, perhaps Segar knew a thing or two extra about spinach and masculine vitality. A radical website extolling the virtues of consuming cholesterol and condemning soy products informs us that vitamin A plays a role not only in our utilisation of protein but in testosterone production as well (Masterjohn 2004). Should we trust this information? Perhaps more research is needed.

Comment, Conclusions and the Way Forward

The research that made this article possible would not have been practicable without the publication of four volumes of Segar's original comic strip cartoons (Segar 2006; 2007; 2008; 2009). This is because a systematic scrutiny of Popeye's comic strip newspaper cartoons would have otherwise involved off-line archive-based research beyond the time or financial resources of an unfunded primary research study by a full time academic criminologist.

Reading real books was essential in order to discover why Segar chose spinach for Popeye, but without the Internet and World Wide Web I would never have learned of their existence.

Was it not for the invention of search engine Google this research would never have happened either. Without the opportunity to "Google" instant information, I would have, like so many other academics, simply taken Hamblin's (1981) published work as true. The Internet, in turn, has facilitated a proliferation of plagiarised, linked, evolving and erroneous SPIDES. Clearly, the production of masses of published

codswallop about spinach, Popeye, iron and decimal errors was aided by an army of unhealthy online believers who fail to fact check their sources.

Hamblin's widely cited BMJ article has inspired few others to get to the bottom of the SPIDES, rather than merely recite the story or modify it with further unsubstantiated information of their own. The only remotely informative³² account of another's attempts to research the work of the nineteenth century and 1930s German and Swiss chemists either alluded to or named in the SPIDES can be found on the Straight Dope Website (Tammi Terrell 2007).

Ironically, new research presented in this article tentatively suggests that the two people attributed with debunking myths regarding the nutritional value of spinach in fact played their own respected roles in perpetuating myths about it: Sherman³³ in 1933 and Hamblin (1981).

In the absence of his ability to date to produce any referenced evidenced to the contrary, it seems reasonable to hypothesize that Hamblin (1981) invented and added the rogue decimal place and the shadowy German scientists elements to existing misleading tales associating Popeye's spinach use with iron rather vitamin A (e.g.: The Science News Letter 1935; Hunter 1971). We might further add to this hypothesis that other writers subsequently added von Wolff and von Bunge to make the SPIDES even more humorously and compellingly believable.

Such hypotheses are there to be kicked around. If they still stand up after our best attempts to beat them death then we should perhaps at least begin to take notice.

To date I have been unable to find one single mention of a historical decimal place error in the iron content of spinach, or of any mysterious German scientists discovering that decimal place error, prior to the publication of Hamblin's (1981) article in the British Medical Journal. But I keep an open mind.

Why, spinach remains today associated in the minds of many members of the public as a good nutritional choice for iron, despite publications in 1935 (The Science News Letter) and 1936 (Kohler et al) of evidence to the contrary, is a mystery. Many nutrition websites to this day promote spinach as a source of iron. It may be important for those seeking to get to the bottom of this mystery to note that five years after the Wisconsin scientists made it known that Spinach was over rated for its iron content that The Southern Medical Journal published an article entitled "Common Nutritional Fallacies" (Weston 1941), which, ironically, recommended spinach as an iron rich food choice.

Analysis of nutrition and school text books from the days of Bunge to the present time might reveal some telling examples of bad science in this area. Media analysis of news features may help determine the role of erroneous academic reports in creating the spinach iron myth. And finally, full academic content analysis of comic strips by

³² Although informative in the first instance accounts from websites such as these cannot be relied upon as valid sources as the contributors are often anonymous and therefore unaccountable outside the community of the website where they publish. The original content cited in these sites should be read by interested researchers and then fact checked.

³³ Sherman et al (1933).

Segar, other authors after his death and of the numerous animated Popeye cartoons is necessary.

Employing healthy scepticism and findings from the primary research conducted for this article, all supported by adequate citation, what we can say with some degree of confidence is the following:

- In 1934, hugely influential biochemists from the University of Wisconsin (Sherman et al 1934) published a rather confusing paper that can easily be interpreted to exaggerate the iron content of fresh spinach twenty fold by attributing to it the iron content of dried spinach. They made no reference to the earlier work of von Wolff or von Bunge and foggily corrected the dried/fresh *Sherman Confusion* in another paper published in 1936 (Kohler et al 1936).
- The first author of the Kohler et al paper (1936) has a Germanic name.
- The dried/fresh *Sherman Confusion* (Sherman et al 1934) was compounded by news reports in 1935 (The Science News Letter 1935) of a major research breakthrough in the University of Wisconsin that only 25 percent of the iron in spinach is nutritionally available.
- The news that spinach is not all it has been cracked up to be in the iron department was covered by those same Science News Letter journalists in 1935 who could not resist making a humorous association between iron, spinach and Popeye.
- Prior to Hamblin's (1981) unsubstantiated story – which makes a deliberately humorous association between spinach, Popeye and iron - there appear to be no published accounts of a decimal place error in early reports of the iron content of spinach.
- Hamblin (1981) is attributed with making the spinach decimal error known to the wider world. But Hamblin, despite having been asked to do so on more than one occasion, is strangely unable to provide a citation for the source of the story. No evidence to support Hamblin's famous story can be found at the time of writing.
- As always Popeye has the last laugh, because in 1932 his creator, E. C. Segar, in fact chose and promoted spinach consumption for its vitamin A content, not iron.

On the basis of available evidence, and current lack of cited evidence to the contrary, it seems that Hamblin (1981) may have tapped into a vein of public and professional ignorance on the history of nutrition and deployed humorous references to Popeye to make his tale memorable. It appears on the face of it at least that an ill-informed public are more likely to associate iron with strength than vitamins and would imagine that it was the iron in spinach which made Segar select spinach for his hero's power. Further, large numbers of the general public may have misunderstood the reasons why they can only absorb a small proportion of the total iron content of spinach. The Science News Letter (1935) says: “25 per cent of the iron in spinach is “available”, as scientists put it. That is, only one-quarter of it is in a form that is usable by the body.” Explanations such as this might possibly have been misinterpreted by many non-scientists to mean that spinach contains so much iron that people can only possibly utilise a fraction of the amount they ingest at any one mealtime. If so, these two factors could have reinforced each other. Remember,

however, this is only a hypothesis. But, if supported by future evidence, it might help to explain why Popeye is so readily associated with iron and why many people still think of spinach as a good source of iron.

It is important to stress at this point that the fact that evidence for a decimal point error by 19th Century scientists cannot be found at the time of writing does not mean that we should say it does not exist.

The philosopher Popper (1959) provides a usefully analogy to explain this, which is taken here from the excellent Philosphy.org website³⁴:

“Karl Popper (1902- 94) was critical of the inductive methods used by science. The empiricist David Hume (1711-76) had argued that there were serious logical problems with induction. All inductive evidence is limited: we do not observe the universe at all times and in all places. We are not justified therefore in making a general rule from this observation of particulars. Popper gives the following example. Europeans for thousands of years had observed millions of white swans. Using inductive evidence, we could come up with the theory that all swans are white. However exploration of Australasia introduced Europeans to black swans. Poppers' point is this: no matter how many observations are made which confirm a theory there is always the possibility that a future observation could refute it. Induction cannot yield certainty.

Popper was also critical of the naive empiricist view that we objectively observe the world. Popper argued that all observation is from a point of view, and indeed that all observation is coloured by our understanding. The world appears to us in the context of theories we already hold: it is 'theory laden'.

Popper proposed an alternative scientific method based on falsification. However many confirming instances there are for a theory, it only takes one counter observation to falsify it: only one black swan is needed to repudiate the theory that all swans are white. Science progresses when a theory is shown to be wrong and a new theory is introduced which better explains the phenomena. For Popper the scientist should attempt to disprove his/her theory rather than attempt to continually prove it. Popper does think that science can help us progressively approach the truth but we can never be certain that we have the final explanation.”

We should not totally reject an alternative possibility then that Hamblin (1981) is either telling the truth or else is right without knowing why.

Hamblin's failure to cite or provide his sources when asked on more than one occasion merely calls his academic reputation into question, because one day a decimal place error making influential 19th century German biochemist might just pop up. If Hamblin never invented the story, it could be that Sherman et al's (1934) potentially confusing representation of 53 mg of iron per 100g of fresh spinach was not of their own making but was perhaps von Wolff's or von Bunge's. However, even if this seemingly remote possibility ever turns out to be true, such a failure by

³⁴ The White Swan argument is, arguably, more limited in some fields of scientific enquiry (see: Pearce 1990)

Sherman et al (1934) to reference original sources would only serve to prove the importance of correctly citing sources in scientific and other academic writing.

If we can find out why apparently erroneous beliefs such as SPIDES and the value of spinach as a superior nutritional source of iron are *lies that will not die* then we are on our way to finding more effective ways to tackle all kinds of socially embedded codswallop. This may be of particular value to the promotion of attitude and behaviour change in areas such as racism and hate crime, problem gambling, drug and alcohol and child abuse; in other words, to tackle useless quackery in many areas ranging from medicine to crime reduction and to take forward knowledge in the study of online urban myths, hoaxes and scams (see e.g.: Young 2010).

We need, therefore, to learn more about the power of apparent *superlies* like the SPIDES. What exactly is it about the SPIDES that enabled it to become so socially embedded that even sceptical academics writing critical papers on the need to be sceptical simply believed in it?

Perhaps new knowledge in this area may teach us ways to implant beneficial “truths”³⁵.

The findings in this article will no doubt come as a surprise to the many journalists, methodologists, statisticians, criminologists, psychologists, nutrition experts, haematologists, health experts, chemists and other writers who have believed in and therefore perpetuated the Spinach-Popeye-Iron-Decimal-Error-Story by writing as though it is a verified fact.

Be warned therefore, authors who do not research the sources of supposedly “known facts” risk misleading themselves and others, and ultimately their work may become the subject of much laughter and delight when their ironic hypocrisy is exposed.



³⁵ The importance and dangers of such “*supertruths*” being superseded by new discoveries, or being used for propaganda and commercial marketing, is a matter of concern.

References

Allexperts.com:

<http://en.allexperts.com/e/p/po/popeye.htm>

Barnett, R (2009) S.C. case looks on child obesity as child abuse. But is it? USA Today. 27 March. http://www.usatoday.com/news/health/weightloss/2009-07-20-obesityboy_N.htm

BBC (2006) Spinach – The Truth. June 9th:
<http://www.bbc.co.uk/dna/h2g2/A11681912>

BBC (2010). Sporty girl from Poole is overweight, says NHS.
<http://news.bbc.co.uk/1/hi/england/dorset/8523707.stm>

Bournemouth NHS 2010 <http://www.bournemouthandpoole.nhs.uk/>Bowering, J. Macpherson Sanchez, A. and Irwin, M. (1976) The conspectus of research on Iron Requirements of Man. *The Journal of Nutrition*. Vol. 106. No 7. July. Pp 985-1074.

Brown, M. (1928). Fargo and the Health Habits: A Chapter from a Community Adventure. *Hygeia* 6: 335-338.

Bunge, G. (1902) Textbook of Physiological and Pathological Chemistry, 2nd English edn transl.. Starling, E and Starling F. London. Kegan Paul.

Burris, R. Baumann, R. and Potter, R. (1990) Conrad Arnold Elvehjem 1901 – 1962. A Biographical Memoir. National Academy of Sciences. Washington DC.
<http://books.nap.edu/html/biomems/celvehjem.pdf>

Carla (2009) Guide to Herbal Remedies: Energetic Spinach. May 13th.
<http://guide2herbalremedies.com/energetic-spinach/>

Carroll, A. and Vreeman, R. (2009) Don't Swallow Your Gum!: Myths, Half-Truths, and Outright Lies About Your Body and Health
St. Martin's. Griffin.

Carroll, L. (1876). The Hunting of the Snark: An Agony in Eight Fits. London. Macmillan and Co.

Copperfield, D. (2006) Wasting Police Time: The crazy world of the war on crime. Great Britain. Monday Books

Coultate, T. (2009) Food the Chemistry of its components. 5th Edition. Cambridge. Royal Society of Chemistry Publishing;

Crook, P (no date) PLC Asset Management:
http://plcasset.com/Nulllius_in_Verba.html

- De-Fact-O (2008) Spinach is high in iron: a popular myth. http://www.de-fact-o.com/fact_read.php?id=2
- Emsley, J. (2008) Nearly as Nature Intended: An exhibition of some curious molecules in the foods we eat. New York Times on the Web: <http://www.nytimes.com/books/first/e/emsley-molecules.html>
- Eswaran, S. (2009) Why Does the grasshopper Not Eat Spinach? Resonance. October. P 984.: <http://www.ias.ac.in/resonance/October2009/p978-984.pdf>
- Fincke, M and Sherman, C. (1935). The availability of calcium from some typical foods. *J. Biol. Chem.*, vol. 110, pp. 421-128
- Gabbatt, A. (2009) E.C. Segar, Popeye's creator, celebrated with a Google doodle. The Guardian 8th Decemebr: <http://www.guardian.co.uk/technology/2009/dec/08/ec-segar-popeye-google-doodle>
- Gates, D. (2010) The Body Ecology Guide to the Ten Healthiest Greens http://www.bodyecology.com/07/08/30/healthiest_greens_guide.php
- Gillooly, M. Bothwell, T.Torrance, J. MacPhail, A. Derman, D. Bezwoda, W, Mills, W. Charlton, R. and Mayet, F. The effects of organic acids, phytates and polyphenols on the absorption of iron from vegetables. *Br. J. Nutr.* (1983), 49, 331 33 1
- Goldacre, B. (2009) Bad Science. London. Fourth Estate.
- Gustavii, B. (2008) How to write and illustrate a scientific paper. Cambridge. Cambridge University Press.
- Hamblin, T.J. (1981) Fake! *British Medical Journal*. Volume 283. 19-26th Decemeber. Pp. 1671-1674.
- Hamblin, T. J. (2010) Personal email communication to the author by email following email request for references for the SPIDES that was reported in Hamblin, T.J. (1981) Fake! *British Medical Journal*. Vol. 283.19-26 Decemeber. pp.1671-1674
- Health and Wellbeing (2006) Can Spinach Make You Strong Like Popeye? <http://health.ninemsn.com.au/whatsgoodforyou/theshow/693977/can-spinach-make-you-strong-like-popeye>
- Hintz, H. (2001) The Use of Humour in Nutrition Education: Peanuts, Popeye, Pretender and Pachyderms. *Nutrition Science*. Volume 21, Number 10.
- Hunter, R. (1971) Why Popeye Took Spinach. *The Lancet*. April 10. pp. 746- 747
- Jackson, S. H. (1938) Determination of Iron in Biological Material. *Industrial & Engineering Chemistry Analytical Edition*. 10 (6), 302-304

- Jaun, S. (2006) Will eating spinach make me strong? The Popeye Effect. The Register. 18th August.
http://www.theregister.co.uk/2006/08/18/the_odd_body_spinach/
- King, C. (1975) Henry Clapp Sherman 1875-1955. National Academy of Sciences. Washington. <http://books.nap.edu/html/biomems/hsherman.pdf>
- Knowles, S. and Gonthier, G (2009) Nutrition Myths in the Hospital. The Pulse: Newsletter of the Taanaki District Health Board. August/September:
http://www.thcl.co.nz/news/documents/pulse_2009_09.pdf
- Kohler, G. Elvehjem, C. and Hart, E. (1936) Modifications of the Bibyridine Method for Available Iron. *Journal of Biological Chemistry*. Vol. 113. pp 49-53.
- Kresge, N., Simoni, R. and Hill, R. (2008). The Role of Copper in Anaemia: the work of Edwin B. Hart. *The Journal of Biological Chemistry*. 283.
- Langley, G. (1995) Medicine and the media: Legal, decent, honest, and truthful *British Medical Journal* .311: 1442. 25 November.
- Larsson, K.S. (1995) The dissemination of false data through inadequate citation. *Journal of Internal Medicine*. Vol. 258. No. 5. pp 445-450.
- Lovett, (2005) The Popeye Principle: Selling Child Health in the First Nutrition Crisis. *Journal of Health Politics, Policy and Law*. 30: 803-838.
- Masterjohn, C (2004) Vitamin A: The Forgotten Bodybuilding Nutrient. The Weston A. Price Foundation. <http://www.westonaprice.org/Vitamin-A-The-Forgotten-Bodybuilding-Nutrient.html>
- Maubossin, M. (2009) See for yourself: The importance of checking claims. Legg Mason Capital Management. Maubossin on Strategy. Dec 2.
http://www.leggmason.com/individualinvestors/documents/insights/D8618-Mauboussin_SeeForYourself.pdf
- McCay, C. (1953) Gustav B. von Bunge 1844 – 1920. *Journal of Nutrition* Reprint:
<http://jn.nutrition.org/cgi/reprint/49/1/1.pdf>
- McKillop, M. (1916) Food values: What they are, and how to calculate them. London. Routledge. <http://www.archive.org/details/foodvalueswhatth00mckiuoft>
- New Yorker Cartoon: <http://www.compedit.com/nygraphics.htm>
- Noonan, S and Savage, G. (1999) Oxalate Content of foods and its effect on humans. *Asia Pacific Journal Clinical Nutrition*. 8 (1) 74-64.
- Nutrasource (2009) The believe³⁶ that spinach contains most iron is a misconception. Jan 10th. <http://blog.nutrasourcehk.com/2009/01/10/the-believe-that-spinach-contains-the-most-iron-is-a-misconception/>

³⁶ This is a misspelling on the website

Oladele, O.O. and Aborisade A.T. (2009) *American Journal of Food Technology*. Volume: 4. Issue: 2. pp.: 66-70

Parke, J. and Griffiths. M. (2004) Gambling addiction and the evolution of the "near miss" *Addiction Research & Theory*. Volume 12, Issue 5 October. pp. 407 – 411

Parsons, L. (1943) Nutrition in Infancy. And Mackay, H. (1943): Nutritional Needs of Infancy. Twelfth scientific meeting – seventh English meeting. London School of Hygiene and Tropical Medicine. May 22nd.
<http://journals.cambridge.org/action/displayFulltext?type=1&fid=767148&jid=PNS&volumeId=2&issueId=1-2&aid=767140>

Pearce, N. (1990) White Swans, Black Ravens and Lame Ducks: Necessary and Sufficient Causes in Epidemiology. *Epidemiology*. Vol. 1. No 1. Jan. pp 47-50.

Philosophy.org. Philosophy of science: Science vs. Religion, from the Renaissance to the Enlightenment. <http://www.philosopher.org.uk/sci.htm>

Popper, K. R. (1959). *The Logic of Scientific Discovery*. London. Routledge.

Poskitt, E (2003) Early history of iron deficiency. *British Journal of Haematology*. Vol: 122. No: 4. pp. 554-562

Rewashdeh et al (2009) Iron Bioavailability of Rats Fed Liver, Lentil, Spinach and other Mixtures. *Pakistan Journal of Biological Sciences*. 12 (4) 367-372.

Rosner (2007). Popeye...Spinach...Iron...and healthy soup. Obesity Newsletter. *International Journal of Obesity*. October. p.23.
http://www.iaso.org/documents/IASOObesityNewsletterOct2007_000.pdf

Rowlands, D. (2005) Anaesthesia News: The Newsletter of the Association of Anaesthetists. No 216. July. P27.

Royal Society: <http://royalsociety.org/Nullius-in-verba/>

Ruegamer, W. R. , Michaud, L., Hart, E.B. and Elvehjem, C.A. (1946) The use of the dog for studies of iron availability. *Journal of Nutrition*. 32: 101-111

Sample, I (2009). From young Mozart to black holes, 350 years of the Royal Society go online. The Guardian 30th November.
<http://www.guardian.co.uk/culture/2009/nov/30/royal-society-online-library-anniversary>

Segar, E. C. (2006) Popeye: I Yam What I Yam. Vol.1. Seattle. Fantagraphics Books.

Segar, E. C. (2007) Popeye: Well Blow Me Down. Vol. 2. Seattle. Fantagraphics Books.

Segar, E. C. (2008) Popeye: Let's You and Him Fight. Vol. 3. Seattle. Fantagraphics Books.

Segar, E. C. (2009) Popeye: Plunder Island. Vol. 4. Seattle. Fantagraphics Books.

Sherman, W.C. Elvehjem, C.A. and Hart.E.B. (1934). Further Studies on the Availability of Iron in Biological Materials. *The Journal of Biological Chemistry*. Vol. 107. NO. 3. pp383-394.

Skidmore, P. and Yarnell, J. (2004) The obesity epidemic: prospects for prevention. *OJM: An International Journal of Medicine*. Vol. 97. Number 12. pp 817-825.
<http://qjmed.oxfordjournals.org/cgi/reprint/97/12/817>

Skorucak A, (2010) Was Popeye Wrong?
<http://www.scienceiq.com/Facts/Spinach.cfm>

Skrabaneck P. and McCormick J. (1992) *Follies and fallacies in medicine*. 2nd ed. Dublin: Tarragon Press.

Sound Medicine (2004). Medical Myth: Iron in Spinach. November 14. Indiana University School of Medicine.
<http://soundmedicine.iu.edu/segment/238/redirect?seg=238>

Spring, C. (2000) Stephen Colbert Causes Chaos on Wikipedia, Gets Blocked from Site <http://spring.newsvine.com/news/2006/08/01/307864-stephen-colbert-causes-chaos-on-wikipedia-gets-blocked-from-site>

Steel, C. M. (1996) Read before you cite. *The Lancet*. Vol. 348. July 20. p.144.

Sutton, M. Parke, J. Perry, B. and John Baptiste, C. (2007) Getting the Message Across: using media to reduce racial prejudice and discrimination. Department of Communities and Local Government. London: Communities and Local Government Publications.
<http://www.communities.gov.uk/documents/communities/pdf/611667.pdf>

Sutton, M. and Tseloni, A. (2009). "Where is the Full Fat Fear of Crime: Has 25 Years of Homogenised Data Misled Criminologists and Policy Makers?" Paper presented at the ESDS Government Crime Surveys User Meeting. December 7th 2009.
<http://www.ccsr.ac.uk/esds/events/2009-12-07/>

Tammi Terrell (2007). Straight Dope:
<http://boards.straightdope.com/sdmb/archive/index.php/t-373244.html>

Templeton, S. (2007). Fat police put children on abuse list. Sunday Times, 28 January. <http://www.familieslink.co.uk/download/june07/The%20Fat%20Police.pdf>

The Science News-Letter. (1935) Spinach Over-Rated as Source of Iron Vol. 28, No. 749. Aug. 17, p. 110

Ultimate Disney (2007) Popeye the Sailor, Volume One (1933-1938). DVD Review
<http://www.ultimatedisney.com/dvdizzy/popeye-volume1.html>

US Department of Agriculture (2009): USDA National Nutrient Database for Standard Reference, Release 22 http://www.nal.usda.gov/fnic/foodcomp/cgi-bin/list_nut_edit.pl

Waitrose (2005) Eat a Rainbow. Waitrose.com. March.
<http://www.waitrose.com/food/celebritiesandarticles/ingredients/0503ss09.aspx>

Weston, W. (1941) Common Nutritional Fallacies. *Southern Medical Journal*: April 1941 - Volume 34 - Issue 4 – pp. 397-400

Walter (2004) Astronautics – that’s what you get out of it. Institute of Astronautics.
http://www.lrt.mw.tum.de/en/interessierte/fs_nutzen_der_raumfahrt.phtml

Weigman, K. (2005) The consequence of errors. European Molecular Biology Organization Report. April 6 (4) pp 306-309.

Wikipedia (2009) T. J. Hamblin. From Wikipedia, the free encyclopedia. Online:
http://en.wikipedia.org/wiki/T._J._Hamblin

Wikipedia Popeye. From Wikipedia, the free encyclopedia:
<http://en.wikipedia.org/wiki/Popeye#Spinach>

Willimott, S. and Wokes, F. (1927) Vitamins A and D of Spinach. *Journal Biological Chemistry* 51. pp887 – 894

Wolff, E. von. (1871) Aschenanalysen von landwirthschaftlichen producten, fabrikabfällen und wildwachsenden pflanzen. Berlin, Wiegandt & Hempel. Available online: <http://www.archive.org/details/aschenanalysen01wolfrich>

Woodward, (2000) Fe in spinach:
<http://mailman2.u.washington.edu/pipermail/phnutr-l/2000-January/013440.html>

World Hunger Relief (2008). Feature Vegetable: Spinach. Newsletter. January 15.
<http://www.worldhungerrelief.org/documents/CSA/CSA%20newsletter%202008-01-15.pdf>

Young, A. (2010). The Strange World of Urban Myths. MSN News. 4th March.
<http://news.uk.msn.com/uk/articles.aspx?cp-documentid=152403035>