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THE ORIGIN OF LIFE: PART 2

by Dale Speirs

Cells.

There is no abrupt line at which one can say that this chemical reaction is non-life and that chemical reaction is biotic. Amino acids reacting in an organic soup are not life. The general agreement is that life is not just autocatalytic reactions, but a combination of autocatalytic reactions inside a protective membrane. In other words, life began the moment the first cell winked into existence.

The evolution of cells seems to have been due to the advantage of protecting autocatalytic reactions behind membranes, a safer approach than leaving them exposed on a clay particle or floating in an organic soup. This suggests that the membranes came first, then accumulated organics inside or some other form of autocatalytic molecules. The interior of such a cell has a different chemistry than the surrounding medium, and is more stable [51]. The questions then are how membranes arose and how they came to wrap up genes into a safe package.

How did membranes evolve? Unlike the genetic system of nucleic acids, which is shared by all living organisms, the cell walls of bacteria, plants, fungi, and algae are of different evolutionary origins [35]. This makes a bit of sense because membranes are not as critical as genes, and different materials can be used without affecting the genes. Some molecules are self-organizing into sheets. Based on a similarity to organelle membranes in cells today (an organelle is to a cell what organs are to animals), it has been suggested that the first membranes were sheets of lipids and proteins stacked in alternate layers, with the lipid and protein molecules at right angles to the plane of the sheet [34]. It wouldn't be too difficult to imagine self-replicating organic molecules becoming associated with lipid films instead of clay particles, and a detached piece of film would easily wrap around into a sphere or more probably a shapeless blob. Layers of lipids or other materials on surfaces such as pyrites would have helped protect self-replicating molecules from overly reactive environments, and from there the layers could have wrapped around the biomolecules.

Modern cell membranes have sophisticated mechanisms to control the entry and exit of nutrients or other substances, but the early membranes were likely just plain leaky. The leaks were small enough to prevent the interior organic molecules from spilling out but large enough to let single-atom or small molecule nutrients in [36]. What would then happen is natural selection. The membranes would hold in various combinations of self-replicating molecules. Some combinations would be more efficient than others, and thus grow faster. Eventually the bag of organic chemicals and its associated membrane would stretch and fission into two or more duplicates. From there, one set of self-replicating molecules would later have an ability to build templates for new membranes, and thus the cell was born.

Another proposal is that life began in hydrothermal springs where the mineral deposits were spongy [37]. The inorganic pores of this spongy material allowed self-replicating molecules a safe place to evolve membranes to coat the inner lining of the pores. Eventually some organic cells evolved. From there, some of those developed the ability to survive and reproduce without requiring a solid inorganic framework. There is also the suggestion that autocatalytic reactions may have first stabilized inside blobs of polysaccharides, from which later membranes evolved [81]. In other words, life developed inside gels, which protected the autocatalytic networks from disruption by the surrounding environment.

Cells Within Cells.

The last major step in the origin of cellular life was the rise of the cell nucleus. With readily-exchanged genetic material, a bacterium would have the problem of genetic noise interfering with its most optimal genes. To protect them, the essential genes were enclosed in another membrane to form the nucleus, a cell within a cell, to help control foreign genetic material.

There are three types of cell lineages, the Archaea, the Bacteria, and the Eukarya. The first two are prokaryotes, with no nucleus. The last, of which we are part, are eukaryotes, with a cell nucleus. Originally it was thought that all the genes in a eukaryote were in the nucleus, but now we know that organelles of the cell have their own genes. Organelles include mitochondria, which all cells have, and which are the respiratory organelles that produce the energy to keep cells alive. Plants have chloroplasts. There are other types of structures such as ribosomes, used to copy molecules via RNA for cell use, and various types of internal membranes that do specialized tasks. The modern thinking is that most organelles were originally independent autocatalytic networks or even organisms that became absorbed by the cells and now live within them as symbionts [65]. Cells are thus microscopic ecosystems combined within a membrane.

These symbionts were absorbed at different times in the evolution of the earliest cells. RNA analysis suggests that fungal and animal mitochondria originated from different species [66]. These symbionts no longer exist independently because they were adapted to a free-living life in a world that no longer exists, and can now only survive within the protection of a cell. A likely scenario is that they were organisms that were engulfed by primitive membranes which also happened to have some other autocatalytic molecules, and the mutual advantages of sharing and exchanging resources gave the proto-cell an evolutionary boost.

It appears that eukaryotes developed from a fusion of some ancient photosynthetic lineage and an archaeal prokaryote [79]. The fusion of two such prokaryotes, one inside the other, allowed the interior one to develop into the cell nucleus, while the organelle symbionts floated about in the rest of the cell.

Uneasy Air That We Breathe.

Any time traveller heading back more than about 540 megayears ago would need air tanks. During the Archean era, that period of time before 2.5 gigayears ago, the Earth was anoxic, with no oxygen in the atmosphere or ocean. The exact composition of the early atmosphere is still being debated, and changes with new geological discoveries. Atmospheric conditions can be determined by the type of sediments being deposited, so the air back then is not a matter of speculation but of studying the ancient rocks to see what types of oxides, sulphides, and other compositions are present. The atmospheric gases react with the bedrock. Methane reactions produce certain types of rocks, carbon dioxide other types of rocks, and oxygen produces oxide rocks.

It is generally agreed that 2.5 to 3 gigayears ago, the Earth was enveloped in a methane/carbon dioxide haze [70]. The exact nature and proportions are uncertain.

If there were higher proportions of carbon monoxide, nitrogen gas, and or water, this would have allowed for a richer mix of organic molecules to be formed and thus speeded up the origin of life that much faster [75]. The atmospheric concentration of carbon dioxide was about 100 times greater than today, which would have meant that rainfall and oceans were very acidic [76]. One would not go for a swim at the beach in those days.

Recent explorations by space probes analyzing the atmosphere of Saturn's moon Titan have shown that the satellite is enveloped in an organic haze of methane and nitrogen gas [72]. This immediately attracted the interest of palaeobiologists who use this as an analogy to proto-life conditions on Earth, and possibly on Titan as well. The huge amount of carbon dioxide in early Earth's atmosphere was removed by precipitation in seawater as carbonate rocks in the early oceans [74]. This has a significant bearing on life because Venus had too much carbon dioxide and too little water, so it was enveloped in a runaway greenhouse effect. Mars had too little of both.

The Great Natural Selection.

The original life forms used reduction chemistry, which does not require oxygen but is less efficient. The reduction ecosystems needed inorganic chemicals as energy sources, but when those ran out, the mutants that had developed oxygen metabolism began their rise [44]. Oxygen became dominant with the advent of photosynthesis, and by 540 megayears ago had built up enough that aerobic life could develop beyond single-cell species [38]. Photosynthesis took hundreds of millions of years to have any appreciable effect after it evolved. Firstly, the free oxygen liberated by photosynthesis reacted with other elements and was tied up as oxides. It took huge amounts of time before there were no more element sinks left to soak up oxygen by combining with it and precipitating out. Secondly, what free oxygen there was in the atmosphere would have been disassociated into ozone [45]. Ironically, the ozone layer protects most of today's atmospheric oxygen from the ionizing effects of space radiation. Eventually the oxygen increased where, even after it had reacted with rocks, atmospheric gases, and developed a thick enough layer of ozone, it began to accumulate as O_2. It also helped that at about this time the planet's volcanic activity and outgassing of methane went through a hiatus, which starved reduction chemistry life forms of their food [88]. This reduction was not as important to early photosynthetic life, who thereby had one more advantage over the old life forms.

This initial rise of free atmospheric oxygen has been detected in the rocks at about 2.2 to 1.9 gigayears ago, and set off a biological cataclysm [41, 46]. Life had evolved under anoxic conditions, and the vast majority of cellular life was adapted to such. To them, oxygen was a poison.

The development of photosynthesis by certain microbes gave the interlopers an advantage, not only because the oxygen generated by the process created new metabolic pathways of greater complexity and more energy, but because it wiped out the competition [39]. This was the second great natural selection after the development of cellular life.

Photosynthetic life first developed in shallow waters for the obvious reason that there is no light in the deeps. It then spread globally, pushing anaerobic life into the deeps. Later the atmosphere was converted to oxygen, and then most of the deep waters gradually became oxygenated by turbulent mixing from the air and surface waters [54]. This was a long, slow process over hundreds of megayears. Land plants did not evolve until about 470 megayears ago, so there was no oxygen source from there.

Photosynthesis generates three times as much energy for cells as relying on Earth ground heat or basking in the Sun's rays to warm up one's metabolism does. It also allows organisms to create new geochemical cycles by actively recombining elements into new molecules. It appears that plants are also responsible for the formation of continents [40]. Earth is the only known planet with granite, which is tectonically recycled weathered bedrock. Plants altered the weathering cycle by changing the geochemistry of sediments and rocks, and by reducing erosion.

There are several different photosynthesis structures, of which chlorophyll is the most common because it is the most energy efficient. Chlorophyll and haemoglobin have remarkable similar structures, being latticeworks with either magnesium (chlorophyll) or iron (haemoglobin) at the core. This suggests a common origin from prebiotic structures. It is known that similar precursors exist naturally in marine waters [42]. These structures all have pores that enable them to capture individual atoms or sub-atomic particles such as electrons (the energy source of photosynthesis) or oxygen atoms (the energy source of blood). From there, one can see self-replicating systems developing that use these lattices as an energy source to reproduce. Photosynthetic organelles, known as chloroplasts, are found within plant cells. They are believed to be ancient symbionts because their reproduction within a cell is independent of the rest of the cell.

Evolving Complexity.

The spontaneous organization of nonliving material leading to primitive organisms was likely a slow process that took years or decades [13]. Although scientists have created building blocks of life under simulated conditions in the laboratory in quick time, the actual synthesis from start to finish will probably take longer than any graduate thesis or research funding will allow. Once cells arose, their genetic material allowed them to build up their complexity from simple genes by additive processes [67]. Genes are essentially logic problem operators, and natural selection picked out the most consistent lines of problem solving. Just as computer software didn't suddenly go from COBOL to 3-D video graphics in one step, so it was that genes built upon their predecessors and added complexity over time.

As evolution proceeded, certain metabolic pathways became locked in by genes, and the patterns of life became more ordered [73]. Entropy no longer applied to life, as it does to most chemical and physical systems. Entropy only works in a closed system, which life is not because it receives energy inputs from the Sun (photosynthesis) and the Earth (chemosynthesis and thermosynthesis). Life is therefore constrained by kinetic laws, which allow the buildup of complexity.

One important concept of genetics is the difference between genotype and phenotype. The genotype is the actual genetic code, and the phenotype is the expression of that code, which is determined by the environment of the developing organism and the sequence in which genes are triggered. For example, tabby cats have striped fur (genotype), but the actual pattern of those stripes varies from one cat to the next (phenotype) depending on the timing of gene activation. In the protolife forms, the earliest genotypes and phenotypes were one and the same [52]. Each gene produced a chemical or reacted with one, and that was it. As cellular life evolved, the gene expression varied with environment, and thus phenotypes were born. For example, a bacterium might find itself living in a methane-rich volcanic vent, very salty water, or a hot spring. The total population of the bacteria, and all life, was a single species that could exchange genes readily. Eventually the gene flow was reduced between habitats and species began to evolve. A gene might trigger itself under one condition but not another, or activate at different times in the organism's development, creating phenotypes.

From there, cells began to aggregate to share resources. The first multicellular organisms were undifferentiated, that is, they had no specialized cells and were simply clumps of cells. The advantage of multicellularism is that it allows cooperation, which is evolutionarily advantageous [78]. About 600 megayears ago the multicellular organism with specialized cells evolved. Division of labour is more efficient than generalist labour. Genome complexity then gradually increased, with more genes developing, more duplicated genes, and more non-adaptive genes. The latter were not harmful, and often came in handy when the environment changed and a hitherto useless gene suddenly had a useful property [55]. Over the next 600 megayears, life evolved to advanced species where individuals cooperated, not just cells and, one of which is now exploring space.

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I HEARD FROM: Sheryl Birkhead, John Held Jr, Franz Zrilich, Phlox Icona, Peter Netmail, Joseph Nicholas, A. Langley Searles, Don Mabie

SEEN IN THE LITERATURE

noticed by Dale Speirs

Natarajan, L.C., et al (2007) **Bone cancer rates in dinosaurs compared with modern vertebrates.** TRANSACTIONS OF THE KANSAS ACADEMY OF SCIENCE 110:155-158

"*Data on the prevalence of bone cancer in dinosaurs is available from past radiological examination of preserved bones. We statistically test this data for consistency with rates extrapolated from information on bone cancer in modern vertebrates, and find that there is no evidence of a different rate. Thus, this test provides no support for a possible role of ionizing radiation in the K-T extinction event.*"

Speirs: The K-T event was the asteroid impact that killed off the dinosaurs.

Zeldovich, K.B., et al (2007) **Protein stability imposes limits on organism complexity and speed of molecular evolution.** PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES USA 104:16152-16157

"*Here we study population dynamics in a model where fitness can be inferred from physical properties of proteins under a physiological assumption that loss of stability of any protein encoded by an essential gene confers a lethal phenotype. The theory provides a fundamental relation between mutation rate, maximal genome size, and thermodynamic response of proteins to point mutations. It establishes a universal speed limit on rate of molecular evolution by predicting that populations go extinct (via lethal mutagenesis) when mutation rate exceeds approximately six mutations per essential part of genome per replication for mesophilic organisms and one to two mutations per genome per replication for thermophilic ones. Several RNA viruses function close to the evolutionary speed limit, whereas error correction mechanisms used by DNA viruses and nonmutant strains of bacteria featuring various genome lengths and mutation rates have brought these organisms universally 1,000-fold below the natural speed limit.*"

Speirs: This article indirectly provides another reason why DNA evolved, namely that it is better than RNA at correcting coding errors.

Storey, A.A., et al (2007) **Radiocarbon and DNA evidence for a pre-Columbian introduction of Polynesian chickens to Chile.** PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES USA 104:10335-10339

"Two issues long debated among Pacific and American prehistorians are (i) whether there was a pre-Columbian introduction of chicken (Gallus gallus) to the Americas and (ii) whether Polynesian contact with South America might be identified archaeologically, through the recovery of remains of unquestionable Polynesian origin. We present a radiocarbon date and an ancient DNA sequence from a single chicken bone recovered from the archaeological site of El Arenal-1, on the Arauco Peninsula, Chile. These results not only provide firm evidence for the pre-Columbian introduction of chickens to the Americas, but strongly suggest that it was a Polynesian introduction."

Firestone, R.B., et al (2007) **Evidence for an extraterrestrial impact 12,900 years ago that contributed to the megafaunal extinctions and the Younger Dryas cooling.** PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES USA 104:16016-16021

"A carbon-rich black layer, dating to 12.9 ka, has been previously identified at 50 Clovis-age sites across North America and appears contemporaneous with t he abrupt onset of Younger Dryas (YD) cooling. The in situ bones of extinct Pleistocene megafauna, along with Clovis tool assemblages, occur below this black layer but not within or above it. In this paper, we provide evidence for an extraterrestrial (ET) impact event at 12.9 ka, which we hypothesize caused abrupt environmental changes that contributed to YD cooling, major ecological reorganization, broad-scale extinctions, and rapid human behavioral shifts at the end of the Clovis Period. Clovis-age sites in North American are overlain by a thin, discrete layer with varying peak abundances of (i) magnetic grains with iridium, (ii) magnetic microspherules, (iii) charcoal, (iv) soot, (v) carbon spherules, (vi) glass-like carbon containing nanodiamonds, and (vii) fullerenes with ET helium, all of which are evidence for an ET impact and associated biomass burning at 12.9 ka. This layer also extends throughout at least 15 Carolina Bays, which are unique, elliptical depressions, oriented to the northwest across the Atlantic Coastal Plain. We propose that one or more large, low-density ET objects exploded over northern North America, partially destabilizing the Laurentide Ice Sheet and triggering YD cooling. The shock wave, thermal pulse, and event-related environmental effects (e.g., extensive biomass burning and food limitations) contributed to end-Pleistocene megafaunal extinctions and adaptive shifts among PaleoAmericans in North America."

Brodie, E.L., et al (2007) **Urban aerosols harbor diverse and dynamic bacterial populations.** PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES 104:299-304

"*Considering the importance of its potential implications for human health, agricultural productivity, and ecosystem stability, surprisingly little is known regarding the composition or dynamics of the atmosphere's microbial inhabitants. Using a custom high-density DNA microarray, we detected and monitored bacterial populations in two U.S. cities over 17 weeks. These urban aerosols contained at least 1,800 diverse bacterial types, a richness approaching that of some soil bacterial communities. We also reveal the consistent presence of bacterial families with pathogenic members including environmental relatives of select agents of bioterrorism significance. Finally, using multivariate regression techniques, we demonstrate that temporal and meteorological influences can be stronger factors than location in shaping the biological composition of the air we breathe.*"

Speirs: For purity of essence health fanatics, it should be noted that no matter the quality of what you eat or drink, you breathe in thousands of spores and pollen grains with each breath you take. And that's not taking into consideration what chemical vapours or dust are in the air.

Wilson, J.W., et al (2007) **Space flight alters bacterial gene expression and virulence and reveals a role for global regulator Hfq.** PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES USA 104:16299-16304

"*The bacterial pathogen Salmonella typhimurium was grown aboard Space Shuttle mission STS-115 and compared with identical ground control cultures. Global microarray and proteomic analyses revealed that 167 transcripts and 73 proteins changed expression with the conserved RNA-binding protein Hfq identified as a likely global regulator involved in the response to this environment. Hfq involvement was confirmed with a ground-based microgravity culture model. Space flight samples exhibited enhanced virulence in a murine infection model and extracellular matrix accumulation consistent with a biofilm. Strategies to target Hfq and related regulators could potentially decrease infectious disease risks during space flight missions and provide novel therapeutic options on Earth.*"

von der Lippe, M., and I. Kowarik (2007) **Crop seed spillage along roads: A factor of uncertainty in the containment of GMO.** ECOGRAPHY 30:483-490

"*Feral populations of crop species along roadsides contribute to the uncertainty regarding* *the containment of genetically modified (GM) crops, as the feral populations could promote the persistence of transgenes outside of cultivated fields. We sampled the seed rain from vehicles inside two motorway tunnels in an urban environment to reveal the contribution of crop species to seeds unintentionally dispersed by traffic beyond agricultural production areas. Three species of arable crops, wheat Triticum aestivum, rye Secale cereale and oilseed rape Brassica napus, were among the most frequent species deposited by vehicles inside the motorway tunnels. Each of the three species was clearly more predominant in one direction of traffic. While seeds of Triticum aestivum and Secale cereale were primarily transported into the city, Brassica napus was significantly more abundant in samples from lanes leading out of the city. Seed sources in the local surroundings of the tunnels were virtually nonexistent, and the high magnitude of seed deposition combined with high seed weights suggests a dispersal mechanism different from other species in the sample, at least for Triticum aestivum and Secale cereale. This provides evidence that spillage during transport is a major driver for long-distance dispersal of crops. Our results suggest that seed dispersal by vehicles is the major driver in the recruitment of roadside populations of arable crops, providing a possible escape route for GM crops.*"

Speirs: This is no surprise. It has long been known that field mice are frequently transported by hay bales, and railroad tracks where grain cars are used will become one long wheat field from seed dribbled out the hoppers. There is no uncertainty as the title of this article suggests; we already know for a fact that GM crops will not stay in the fields. I've seen some remarks by researchers or legislators that farmers should scrub their machinery before moving from one field to another, an impractical notion to say the least. The genes will spread.

Piyapong, C., et al (2007) **A cost of leadership in human groups.** ETHOLOGY 113:821-824

"*Group living is the result of a dynamic trade-off between associated costs and benefits. However, these costs and benefits are not necessarily distributed equally across different spatial positions of groups which may result in different fitness returns for individuals occupying different positions in groups. Here we consider whether leadership of a group during a navigation task in humans may have a specific cost associated with it. Pairs of students performed a counting task whilst walking through two obstacle courses, once as leader and once as follower. We found that leaders made significantly more errors in the counting task than followers suggesting that there is an attention cost associated with leadership/navigation behaviour.*"

Ross, D., et al (2007) **Musical intervals in speech.** PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES USA 104:9852-9857

"*Throughout history and across cultures, humans have created music using pitch intervals that divide octaves into the 12 tones of the chromatic scale. In the present study, we analyzed a database of individually spoken English vowel phones to examine the hypothesis that musical intervals arise from the relationships of the formants in speech spectra that determine the perceptions of distinct vowels. Expressed as ratios, the frequency relationships of the first two formants in vowel phones represent all 12 intervals of the chromatic scale. Were the formants to fall outside the ranges found in the human voice, their relationships would generate either a less complete or a more dilute representation of these specific intervals. These results imply that human preference for the intervals of the chromatic scale arises from experience with the way speech formants modulate laryngeal harmonics to create different phonemes.*"

Pagel, M., et al (2007) **Frequency of word-use predicts rates of lexical evolution throughout Indo-European history.** NATURE 449:717-720

"*Among more than 100 Indo-European languages and dialects, the words for some meanings (such as 'tail') evolve rapidly, being expressed across languages by dozens of unrelated words, while others evolve much more slowly-such as the number 'two', for which all Indo-European language speakers use the same related word-form1. No general linguistic mechanism has been advanced to explain this striking variation in rates of lexical replacement among meanings. Here we use four large and divergent language corpora (English, Spanish, Russian and Greek) and a comparative database of 200 fundamental vocabulary meanings in 87 Indo-European languages to show that the frequency with which these words are used in modern language predicts their rate of replacement over thousands of years of Indo-European language evolution. Across all 200 meanings, frequently used words evolve at slower rates and infrequently used words evolve more rapidly. This relationship holds separately and identically across parts of speech for each of the four language corpora, and accounts for approximately 50% of the variation in historical rates of lexical replacement.* "

Lieberman, E., et al (2007) **Quantifying the evolutionary dynamics of language.** NATURE 449:713-716

"*Human language is based on grammatical rules. Cultural evolution allows these rules to change over time. To quantify the dynamics of language evolution,* *we studied the regularization of English verbs over the past 1,200 years. Although an elaborate system of productive conjugations existed in English's proto-Germanic ancestor, Modern English uses the dental suffix, '-ed', to signify past tense. Here we describe the emergence of this linguistic rule amidst the evolutionary decay of its exceptions, known to us as irregular verbs. We have generated a data set of verbs whose conjugations have been evolving for more than a millennium, tracking inflectional changes to 177 Old-English irregular verbs. Of these irregular verbs, 145 remained irregular in Middle English and 98 are still irregular today. The half-life of an irregular verb scales as the square root of its usage frequency: a verb that is 100 times less frequent regularizes 10 times as fast. Our study provides a quantitative analysis of the regularization process by which ancestral forms gradually yield to an emerging linguistic rule."*

Tanaka, F., et al (2007) **Socialization between toddlers and robots at an early childhood education center.** PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES USA 104:17954-17958

"A state-of-the-art social robot was immersed in a classroom of toddlers for >5 months. The quality of the interaction between children and robots improved steadily for 27 sessions, quickly deteriorated for 15 sessions when the robot was reprogrammed to behave in a predictable manner, and improved in the last three sessions when the robot displayed again its full behavioral repertoire. Initially, the children treated the robot very differently than the way they treated each other. By the last sessions, 5 months later, they treated the robot as a peer rather than as a toy. Results indicate that current robot technology is surprisingly close to achieving autonomous bonding and socialization with human toddlers for sustained periods of time and that it could have great potential in educational settings assisting teachers and enriching the classroom environment."

Cogan, B. (2007) **"Was he safe or was he out?": Sports zines and questions of authenticity.** JOURNAL OF POPULAR CULTURE 40:808–830

Study on the development of sports zines, claiming they arose from punk zines. Cogan seems vaguely aware that zines existed for decades prior, but concentrates on the post-1970s milieu.

SHARP PRACTICE IN MILLARVILLE, ALBERTA

by Dale Speirs

The village of Millarville is about 40 km southwest of Calgary, centre to centre. Its first postmaster was Malcolm T. Millar, who opened the post office in April 1892. Millar had previously been postmaster at Fort Walsh, Saskatchewan, while serving with the North West Mounted Police. In 1911, he sold his general store and gave up the postmastership [1].

The mail service to Millarville was from Calgary through Midnapore and Priddis. It was semi-weekly on Wednesday and Saturday, and was carried by horse and wagon/sleigh [2]. Midnapore was swallowed up by Calgary in 1979 and no longer exists as a separate post office. Priddis and Millarville are still some distance from the sprawling city but the district today is heavily dissected into acreages owned by petro-executives commuting into Calgary.

In the first decade of the 1900s, the Canadian Post Office noticed some strange anomalies in the revenue of the Millarville post office. Gross revenues are shown in Figure 1, with the larger village of Midnapore for comparison [3]. These figures were highly suspicious to the Post Office auditors.

Figure 1: Gross post office revenues.

Year	Millarville	Midnapore
1908	$ 951.68	$ 292.12
1909	1766.82	624.82
1910	2029.44	1122.82
1911	1367.27	1393.78
1912	685.25	1050.51
1913	482.40	1062.34

Millarville is off the beaten track in the Rocky Mountain foothills, while Midnapore straddles the main highway (Highway 2, also known as Macleod Trail) running south from Calgary to Fort Macleod and thence to the American border. Highway 2 was and still is the major north-south trade route in Alberta. Although the first decade of the 1900s was a prosperous time as settlers poured in and land was taken up by homesteaders, it was not believable that Millarville was doing so much better than Midnapore.

The auditors quickly narrowed down the excess revenue to the sale of postage stamps. Rural postmasters were paid a commission on stamp sales, but Post Office regulations prohibited the use of stamps in bulk for payment of trade debts.

This regulation came about because the majority of rural post offices were located in general stores. Wholesalers often accepted sheets of stamps as payment (they used them for their substantial mailing volumes), and individual stamps were used as small change with retail customers. By paying his debts in stamps purchased at face value from his post office, the storekeeper would pay the same dollars and cents whether in cash or as stamps. But, wearing his postmaster's hat, he would gain a commission on the sale of those stamps. The temptation was obvious. For small accounts paid in stamps, where the volume did not distort the gross returns, the storekeeper/postmaster would usually get away with it. For large volumes that suddenly turned a village post office into a major stamp seller, this was waving a red flag at the auditors.

The auditors determined that the volume of mail going through Millarville did not match the sales in stamps. Millar countered that many settlers bought stamps at his store but mailed their letters when they went into market towns such as Midnapore or Calgary, because this gave faster service than the semi-weekly service at Millarville. The case went to court. The Post Office was able to show that $200 to $400 per year of the suspicious sales were bulk stamps paid to GF and J Galt Ltd, a Winnipeg wholesaler who supplied general stores such as Millar's. Unfortunately the Post Office was not able to prove the other bulk stamp payments. Consequently, they were only able to retrieve commissions paid out on the Galt account.

In his summation, the judge remarked of Millar:

"The defendant on his examination for discovery said that he "could pretty near figure it out at home". I think that he not only could, but that he should have done so. And yet he came to trial with his mind a perfect blank on the subject." [4].

After Millar left his postmastership in 1911, the gross revenue of the Millarville post office suddenly dropped. Presumably his replacement was a more honest man. It was not the general economic conditions that caused the drop, since the Midnapore postal revenues held steady.

References.

1] Library and Archive Canada (downloaded 2006-03-21) Post offices and postmasters. ARCHIVIANET, www.collectionscanada.ca/archivianet/post-offices

2] Blakley, Jean (1979) Millarville store and post office, 1892-1941. in FOOTHILLS ECHOES. Published by Millarville Historical Society, pages 33 to 35

3] Canada Post Office (1909 to 1913) Report of the Postmaster General for the year ended March 31, 19xx. SESSIONAL PAPERS #24, Appendix C

4] Walsh, J. (1914-12-19) Postmaster General v. Millar. ALBERTA SUPREME COURT, Docket #19 DLR 184