

Writing and the formation of the modern mind¹

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Father Walter Ong, a famous and unlikely student of the differences between oral and literate cultures, described writing as the most momentous of all human technological inventions, the technology which has shaped and powered the intellectual activity of modern man.¹ Presumably, that is, after syntactic language itself.

Table 1: Chronology of reading-writing technologies

Ideographs 4000 BCE	Rag paper 105 CE	Typewriter 1873
Pictographs 3500 BCE	Stable ink 400 CE	Carbon filament light globe 1880
Cuneiform writing 3000 BCE	Quill pen 700 CE	Radio telegraphy 1890s
Phonograms, Hieroglyphics 3000 BCE	Porcelain movable type 1040	Photocopier 1958
Dictionaries 2800 BCE	Spectacles 1250	Word processors 1970s
Books (papyrus rolls) 2800 BCE	Press with metal type 1436	Proto-internet connected 1980
Archives 2500 BCE	Cursive handwriting 1495	Fax 1980s
Mail 2100 BCE	Printed books 1500	World wide web 1989
Encyclopaedia 1800 BCE	First printed newspaper 1605	Electronic libraries 1980s
Steles 1760 BCE	Electric telegraph 1843	Text messaging 2000
Phonetic alphabet 1500-1400 BCE	Paper from wood pulp 1844	
Public libraries 300 BCE		

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Writing systems developed and spread in two waves (see Table 1). The first, based on pictographic forms, began in Sumer some 3500 BCE and dispersed from there through Mesopotamia to Egypt, Europe, India and China. Writing systems in the second wave, beginning in the late Bronze Age, were alphabetic, meaning that they used one sign to represent one sound. A good example is the Phoenician alphabetic system which gave rise to Hebrew, Aramaic and early Greek; and then, via Greek, to Latin and Cyrillic. Around 800 BCE the Greeks invented signs for vowel sounds, making theirs the first complete alphabet with both consonants and vowels.

As the Bronze Age progressed, and societies became more complex, writing was increasingly used for practical purposes such as keeping records of transactions and contracts; transmitting instructions from supervisors to workers; and providing permanent, accessible public statements of proclaimed laws. In this context writing was a technology which provided certainty as to what had been communicated and which allowed communication across time and space.

It was towards the end of the Bronze Age that culturally-important stories and narratives which, till then, could only be transmitted orally began to be written down, the first perhaps being the Zoroastrian Vesta (c.1500 BCE) and the Hebrew Torah (c.1200 BCE). The oldest of the Indian Upanishads has been dated to around the eighth century BCE---it is the philosophy of the Upanishads which underpins Hinduism, Jainism and Buddhism. In China Confucian writings date from c.500 BCE.

It is hard to see how the great religions could have spread and matured without such sacred authoritative texts, unchallengeable as they were by the mindset of the time. Think also of the importance of the New Testament and the Koran in the following millennium. Certainly the Greeks and Romans had no sacred or revealed texts of any stature and their religions withered. Rather, texts, particularly for the Greeks, became vehicles for the elaboration of philosophical and scientific inquiries and for the 'fixing' of foundation myths such as 'Homer's' two epic poems, the Iliad and the Odyssey (transcribed c. 700-650 BCE).

We can speculate that it was only with the transcription of foundation myths and the later realisation that the world was no longer as it was that the concept of historical time entered the consciousness of newly-literate societies. Mircea Eliade in *Cosmos and History* suggested that it was the Hebrews, the first truly alphabetic people, who developed a sense of 'one-way' time---an accreting, non-repeating sequence of events against a backdrop of cosmic cycles. Eliade's bold hypothesis, known as *the myth of the eternal return*, is that preliterate people inhabit a cyclical time wherein, they believe, their periodic ritual reconstructions of mythic events actually recreate (reactualise) those events and return the world to its beginnings.²

The unsettling idea that historical time had to be discovered provides a first example of the process which this essay sets out to capture and present as plausible, namely, the coevolution of human thought with writing-reading technologies. Changes in writing-reading technologies have catalysed important changes in the way humans think and in what we think about. We shape our technologies and thereafter they shape us!

Perhaps we should start with the prosaics. A scan through Table 1 suggests that the evolutionary trend in writing-reading technologies has been towards easier recording of the spoken-imagined word and towards facilitating the accumulation-transmission of written words. One result has been that the stock of readers, authors and words available to be read has grown geometrically. “There is no end to the writing of books,” said Ecclesiastes.

As for the mind, vocabulary is the best single indicator of how our minds have changed since, say, the late ice age. While words do get lost over time, the richness of modern vocabularies reflects giant leaps in how we perceive the world, both inner and outer, how we describe and conceptualise it and how we understand linkages between concepts. Another indicator is the increased range of cognitive tasks for which language has become the primary tool, eg simple logical operations which were not available to the People of the Book.

How can we possibly appreciate the pre-literate mentality? How can we think like our ancestors? The answer is that we cannot but, with the aid of intelligent informed speculation by people like Walter Ong, Julian Jaynes and Marshall McLuhan, we can make some plausible inferences³. For starters, differences between modern minds and (say) Cro-Magnon minds are cultural. A Cro-Magnon baby could be raised to be a merchant banker. But, raised in Cro-Magnon times, her behaviour would be largely set by custom and tradition. She would have a weak sense of self and be uncritically accepting of verbal commands and assertions. Indeed thinking her own novel thoughts would be discouraged. Perhaps, if Jaynes is right, she was not even conscious, depending how one understands that fraught word, eg could she say “I am aware that I am thinking about this evening’s meal”? Her understanding of how the natural world works would be trapped in the animistic and the magical: stuff happens because spirits make it happen; things which are superficially similar can interact causally.

The age of manuscript culture

The transition from an oral to a literate or scriptal culture can be seen most clearly in the flowering of Greek thought, culminating by the sixth century BCE in a society where an elite had acquired sufficient cognitive skills, sufficient vocabulary (including the vocabulary of subjective consciousness) and sufficient shared knowledge to debate, individually and collectively, the nature of the world and society and how these might be better managed. For example, democracy was a social technology made possible, at least in part, by the Greek recognition that people are individuals as well as class members. Speculation was explicitly recognised and ardently pursued. More generally, the Classical and Alexandrian periods of Greek civilization, through their contributions to language, politics, pedagogy, arts, science, and philosophy, laid the foundations on which, eventually, the European Renaissance would be built.

The Greek capacity for systematic thought equalled ours. They knew how to trial candidate behaviours in the mind at low cost, and how to bring disparate ideas into a consistent harmony. They knew how to use premises to underpin an argument. They were able to challenge the truth of comforting beliefs.

But long before the Greek awakening, and their invention of the vowels which allowed the elusive world of sound to be captured visually, writing and texts had begun to kill off the tribal mind. When Hammurabi, around 1780 BCE, incised his laws on steles (death to adulterers!), he replaced the previously unquestionable authority of a vocal command with an alternative authority and, critically, created the novel idea that there might be reasons for not accepting the voice of authority. And if Jaynes is right, writing helped destroy many late Bronze Age gods for the same reason. Mind you, the gods were already in trouble because of their failures, via their priestly mouthpieces, to provide sound advice under the chaotic conditions of the time. In reality, custom and tradition were failing to cope with a changing world and ideas about alternatives were welcome. It then fell to the Greeks to boost this breakthrough into a “technology” of actively seeking and recording speculative ideas.

By now though, the thinking process was being transformed in an even more fundamental way. To a large extent pre-literate thought in clichés abstracted from their prodigious memories. The bards in oral-aural cultures relied on mnemonics and verbal formulae to store stories like the Iliad. The act of creating an original text---the “new” way to store knowledge---turned thinking into an exercise where consciousness is searched for relevant thoughts; visual symbols of those thoughts are then arranged sequentially according to certain rules. By Plato’s time (429- 347 BCE) the Greeks were doing this routinely and the old ways of thinking were being abandoned. This is why Plato wanted to exclude poets from his Republic!

Notwithstanding, visual and oral-aural modes of communicating have co-existed and co-evolved till the present day. Logos never did replace mythos. Even in Plato’s time, the art of rhetoric could only be studied from “written down” speeches. People read aloud and slowly till well after the invention of the printed book. Instruction in mediaeval universities was via dictation and dialogue. In the 20th century there were still prominent philosophers committed to dialogue and opposed to book writing.

While writing out a narrative freezes the words spoken and renders it available in canonical form on demand, it does not wholly capture the experience of listening as the owner of the narrative delivers it. Written words are always a reductive abstraction from a total situation which is more than verbal. Inflections, emotions, emphases etc are lost. Marshall McLuhan has dwelt on the psychological consequences of absorbing information visually rather than aurally. For example, written information is acquired by visually tracking an end-to-end sequence of “word packets” while aural information arrives as a free-wheeling multi-faceted mosaic of meaningful sounds. McLuhan and others credit this upgrading of the visual sense with bringing on the Greek discovery of the concept of Euclidean space with its three uniform, continuous dimensions.⁴

While not so momentous as creating space and time, writing contributed in other important ways to the evolution of cognitive capabilities and the buildup of collective knowledge. First, multiple individuals can learn from the writer of a text (ie, an extended discussion) even if he/she is distant or dead. In principle that can also happen in an oral culture (via teachers) but the scale is likely to be different. Given multiple copies of texts and a core of people able to read (libraries were invented in the late first millennium BCE), more people will be holding more knowledge in common in a literate society than in an oral society of the same size. This in turn will mean more people primed to contribute, through learning, to the creation of further knowledge.

Texts themselves provide a stable starting point for ongoing verbal dialogue about their truth or about how the thinking they embody might be extended.⁵ But a written text has several advantages over verbal discourse as a means of evaluating and upgrading an argument or exposition. Improving a written text can be treated as an iterative task, reviewing and revising one's previous thoughts. Selectively rereading what you have written reloads your working memory, sometimes in novel ways. Rewriting involves a dialectical process in which product and process, content and the tacit rules for writing persuasively and logically, have to be constantly harmonised. Reasons have to be crafted and conclusions synthesised.

In contrast, the tacit rules of *spoken discourse* are much looser, a game of verbal ping-pong which can easily wander. It is much easier to get away with sloppy thinking in discussion than on paper. On balance, you are more likely to "know what you think" when you see what you have written than when you listen to what you say!

Writing, being slower than talking, offers more opportunities to be creative, to reflect, to generalise, to abstract, and to integrate ideas. It encourages introspection, including the push to find words to capture the emotions which are expressed otherwise through gesture, mien etc when speaking. Metaphor is particularly important as a technique for understanding, exploring, capturing and, eventually, naming fuzzy feelings and values.⁶ And insofar as writing gradually evolved syntactical structures capable of expressing metaphors, it may have played a pivotal role in the invention and experiencing of consciousness and selfhood.⁷ Ong is one who says that shifts from pre-logical to 'rational' consciousness can be most economically explained as shifts from orality to various stages of literacy.⁸

Against these positives, the difficulties of using and learning from early texts need to be kept in mind. In Plato's time a library's documents were stored in unlabelled jars; there were no spaces between words, sentences or paragraphs and no punctuation marks or capitals; texts usually had no contents listing and no pages.

The shift to a typographic culture

Notwithstanding its brilliant start, manuscript culture barely survived the European Dark Ages that followed the fall of the Western Roman Empire. Some Greek and Roman learning from the golden age of manuscript culture was preserved in a few monasteries but, for several hundred years, it fell to Islamic

scholars in several great university cities to retain substantial knowledge of Greek learning. It was not till c.1300 CE, beginning in Italy, that a revitalisation (renaissance) of European culture broke out, challenging the power of both the feudal political system and its partner, a deeply conservative and corrupt Christian church.

And then, in 1436, came the trigger that set off a cultural explosion, a period of rapid, accelerating cultural evolution: Johannes Gutenberg combined a number of pre-existing technologies (the wine press, paper, ink, replaceable wooden or metal letters) to produce the first (debatably) printing press. By 1501 there were 1000 printing shops in Europe, which had produced 35,000 titles and 20 million copies of books, almanacs etc.

BOOKS THAT CHANGED THE WORLD

The great scholar Erasmus re-translated the New Testament in 1516 and within a year Martin Luther had initiated the Protestant Reformation. As bibles tumbled from the presses, ordinary people could, for the first time, study the Christian story for themselves. The market for books in languages other than Latin boomed and this had the side-effect of fostering senses of regional unity and nationalism. Mercantile capitalism and Protestantism emerged as forces which would create states and empires independent of Rome and feudalism.

Printed books continued to change the world through the European Enlightenment of the 18th century. Tom Paine's tracts fuelled both the French and American revolutions. His *Rights of Man* became the cornerstone for thinking about another of humanity's truly great inventions, namely human rights. And in the 19th and 20th centuries the works of Freud and Marx changed the world again.

We are talking here of books as agents of cultural change because of the ideas they contained. But portable books have, just as importantly, changed individual prospects for leading fulfilling lives: They have democratised literacy and, by giving people access to the thoughts of others, have fostered individuality.

THE INVENTION OF STANDARDISATION

Let me turn now to a quite different way in which the invention of printing transformed the human mind. The invention of printing was also the invention of *standardisation*, an idea, a metatechnology (a technology for implementing other technologies), which is fundamental to the practice, *inter alia*, of bureaucratic organisation, industrial capitalism, scientific research, law, education and commerce. Like space and time, standardisation, the explicit adoption of and commitment to behavioural norms, is one of those generic ideas which are so big that, paradoxically, they are all but invisible. It is the background technology which allows people to coordinate with each other.

Book printing was the world's first mass production process. It is a process in which standardised inputs are fed through a repetitive operation to produce standardised outputs. Henry Ford was a copycat! More than this, as books were produced in increasing numbers they became more standardised, more like each other with respect to page layout, letter shapes, spelling, punctuation and word meanings. This loss in variety vis-à-vis the idiosyncrasies of manuscripts gave books a relatively greater usability.

In general, standardisation is a metatechnology which reduces the costs of communicating and implementing recipes for social, cognitive and material technologies. Provided the technology user understands the relevant standards, it does this by increasing their prior confidence as to what a recipe (really) means and in the likely qualities of the product. Once shown the way, the Renaissance mindset was to embrace standardisation. It is not too much to say that, from the Renaissance to the 21st century, it has been standardisation, including standardised money, which has allowed transactions and coordination between the specialist sectors of a multi-sectoral economy to take place.

Electronic culture

The invention of the telephone in the 1880s and radio broadcasting in the 1890s introduced radically different ways of projecting speech through space. The gramophone allowed speech to be projected in time but it was a mechanical rather than an electronic invention like the much later tape recorder. Television was a prosthesis which allowed both speech and bodily presence to be projected in space and time (and allowed extension of our field of vision).

Marshall McLuhan has argued that these new technologies have effected yet another major shift in the way people think and behave, that we are returning to the oral-aural culture of tribal societies. We are spending much more time talking to each other and relatively less time reading and writing. More than that, he says, the world has become, in his famous phrase, a "global village" where radio and TV have created a shared mythic structure (Hollywood?) and a collective mind.

One symptom of this mind-shift is what might be called a retreat from the standardisation which has been a fundamental and pervasive part of typographic culture or, more generally, the modern world. I certainly have an impression of declining standards in the logical presentation of arguments---coupled with greater use of emotional appeals. Another example is the greater use of a Newspeak in which the meanings of words are deliberately distorted, again to manipulate emotions.

For the present analysis however, the question to be asked is whether electronic technology has changed the way we think by changing the way we read-write? At this stage the answer, I judge, is No. There is no doubt that word processors, hypertext, voice recognition technology, searchable electronic libraries etc have ramped up the efficiency and the reach with which we both read and write. But I cannot see that our thinking processes differ from those of our grandparents. Just to be clear there, the subject matter is obviously different.

Backtracking and pathfinding

So, humans came out of the last ice age some 12-15 k years ago as hunter-gatherers living in aural-oral societies. As they learned to be farmers and herders they slowly established societies where decisions were made by custom and tradition; people believed in animism and magic, and novel thoughts were discouraged and even feared. Eurasia's people were gradually gathered into city-based states and empires, frequently at war with each other. In the sense of being reflectively aware of their own thoughts, people in these Bronze Age and late Bronze Age societies were probably not even conscious.

Things began to change when, at the end of the Bronze Age, people started writing down their myths. They became aware of one-way time. They became aware that there can be alternative ways of viewing the world. In the last centuries before the Common Era the Greeks were most certainly conscious. They learned to catch their thoughts on the wing, record them and debate them. They carved space and time out of the natural world and they looked inwards to find that the residents were not gods but people called I and Me.

These bright treasures gathered dust through the Middle Ages but emerged, along with the Abrahamic texts, to feed the hungry presses of Renaissance Europe. Book printing as a prototype technology, and the waves of ideas inside the new books drove the world to change, and change again. Once they could be powered by coal and oil, standardised industrial technologies replaced, more than replaced, man and beast. Social organisation and values tagged along behind as Marx said they would. But the knowledge to keep the whole rambunctious show on the road was book knowledge, transmitted and updated from one generation to the next.

We are now in an electronic age in which book knowledge continues to accumulate, not so much to transform an ever more complex society, but to service it. Our electronic prostheses give us the illusion that we can quarry what is needed from mountains of information and even do a little landscaping. The scale at which people can, and do, communicate with others, orally and visually as well as textually, has grown enormously since the 19th century. More than that, there has been a rebalancing of sensory contributions from the textual towards the oral and the visual. Social and employment advantages accruing to people with an aptitude for literacy have declined. At the same time, communications technologies are converging in the sense that interconversions between oral and textual versions of messages are ever easier.

Several conclusions poke through. One is that the task of understanding the role of writing in shaping the human mind has now been absorbed into that of understanding the role of something more generic, namely, digital communications technology. A more tentative conclusion is that while the range and size of tasks being undertaken by human minds continues to grow, the cognitive tools being used for those tasks remain much as they have been for several thousand years. Perhaps they have been sharpened and spread around but they are not fundamentally different: you could have a useful discussion about thinking with Socrates if he turned up. There is bite in the aphorism that the history of Western philosophy is a series of footnotes to Plato.

If so, as a closing question to chew on, we might ask where the mind might go from here? Is the natural brain, through genetic evolution, individual learning, acculturation or self-organising behaviour in collaboration with other brains going to think in a markedly different way as we move through hundreds and thousands of millennia to come? For example, might reasoned behaviour based on knowledge from past learning and a capacity for problem solving increasingly replace instinctual behaviour? Or, putting this another way, will we learn or evolve to better suppress instinctual behaviours which are readily accessible to modern people but which we judge to be maladaptive in a post-Neolithic world?

Will we learn to routinely detect the ego's protective distortions of reality? Some certainly think we are at a transition point on a path between behaviour being controlled by reason and being controlled by instinct and culturally-fixed behaviour. Reason requires dedicated neural networks, is metabolically expensive and is prone to various operating weaknesses such as a poor capacity to estimate and combine probabilities or to factor in longer-term consequences. Freud and Marx both debunked reason in their different ways. Freud saw it as rationalising the satisfying of suppressed desires while Marx saw it as rationalising class interest. Postmodernism revives the perennial view that only experience, not reason, can produce knowledge. For example, might we learn how to experience, at will, a state of heightened awareness of ourselves and our surroundings, what Colin Wilson calls 'perceiving reality directly'? I am thinking of something like Abraham Maslow's 'occasional peak experiences' in which people have moments of intense happiness as they apprehend their life-situation and pay attention to the world around them.⁹

Or, looking inwards rather than outwards, could we become more mystical? Mystical experiences, what Aldous Huxley called 'mind-at-large', are most readily understood as recapitulations of the stage in human evolution which preceded rational thought (giving reasons for choices) and individual consciousness, of times before there were egos.¹⁰ In other words, the world as experienced through the mind of an early hominid. More prosaically, control by the neocortex is being suppressed in favour of the limbic brain. Achieving widespread access to the mystical state has been foreseen as a basis for universal empathy with others, to foster a sense of oneness with the world and as a foundation for the religious dimension of a universal culture.

More generally, might we learn how to consciously and routinely access the right brain's activities (the sub-conscious mind) or even the brain stem's autonomic activities (eg as it regulates blood pressure)? There is evidence that yogic and meditative techniques can show the way here, not to mention psychoanalysis and psychotropic drugs such as mescaline. Carl Jung mastered the ability to dream while awake (not quite like daydreams), what he called *active imagination*, as a means of accessing the unconscious activities of his right brain and of working towards optimal collaboration and understanding between his left brain and right brain 'selves.'¹¹

There are various other presumed improvements that have been foreseen. Alan Snyder has suggested that, in time, everyone might learn to release powers such as *idiot savants* display, eg drawing like da Vinci, composing like Bach and performing amazing mental calculations.¹² Others foresee that we will learn how to massively improve both short-term and long-term memory, without producing information overload.¹³ In fact, it is commonly believed that humans use only a small fraction of the brain's information processing capacity and that harnessing such more fully might accelerate both biological and socio-cultural evolution, although not necessarily in expected directions.¹⁴

Consonant with the idea of the 'underused brain', William Calvin, a neurophysiologist, has foreseen the possibility of retraining alternative cortical areas to replace lost functions and to break up obsessions and hallucinations. Nonetheless, competition for cortical 'territory' is a well-established principle. Thus if nerves serving a certain function develop early in a particular part of the cortex, then nerves which serve other functions may be inhibited from developing in that same area. This leads to Merlin Donald's idea of *cognitive tradeoffs* in which training up certain skills can lead to a loss of other skills.¹⁵ Could one implication of this for the future be that people are trained to be specialist thinkers in certain areas, knowing that this may reduce their capacities in other areas?

At the heart of problem-solving capabilities lies *intelligence* which, in general terms, is the capacity to perceive relationships between things. We may learn how to train this capacity more fully or we may develop psychopharmacological drugs which enhance general or specific intelligences. Under either approach there will be some selection pressure favouring those who learn well or who respond well to 'smart pills'.

Learning to perceive relationships between things which are widely separated in space or time has not come easily to the human lineage. Hunter-gatherers relied on instinct to cope with seasonal change and variation. The peasant and the herder learned to look ahead a whole year and, eventually understood the 18 year lunar cycle. But looking ahead for several human generations has generally proved too much for our newly developed rational faculties; the part of the brain which controls impulsivity is still developing. Or, perhaps we do have some such capacity but choose not to exercise it? Or, perhaps in an uncertain world it is entirely rational to heavily discount the foreseeable future? If there do not appear to be any net survival or welfare benefits from further extending human planning horizons, long-term planning will not be pursued by our descendants any more actively than we do.

Finally, learning to think in terms of networks of causation (you can't do just one thing) rather than chains of cause and effect has proved similarly difficult. Early humans learned to deal with problems on an *ad hoc* basis and the need to see a problem embedded in the context of other problems rarely arose. We still find it difficult to believe that solving a problem generates other problems, not to mention new selection pressures. Can we move beyond linear thinking?

The verdict must be that, for an adolescent species, we have done quite well and, looking to the future, the panels on Blake's doors of perception are scrubbing up nicely.

¹ Walter Ong (1982), *Orality and Literacy: The Technologizing of the Word*, Methuen, 1982.

² Mircea Eliade (1954), *Cosmos and History: The Myth of the Eternal Return*, trans. W.Trask, Princeton, NJ: Princeton University Press.

³ Marshall McLuhan (1962), *The Gutenberg Galaxy: The Making of Typographic Man*, University of Toronto Press.

Julian Jaynes (1976), *The Origin of Consciousness in the Breakdown of the Bicameral Mind*, Houghton Mifflin.

Walter Ong, *ibid*

⁴ WT Gordon (1997) *McLuhan for Beginners*, Writers and Readers , New York.

⁵ Sacred texts are an exception here. Because they cannot be adjusted to reflect a changing world, it is their interpretation that becomes a source of debate.

⁶ AN Whitehead notes the difficulties Plato, a metaphysician of genius, had in making language express anything beyond the familiarities of everyday life and goes on to say that it is misleading to study the history of ideas without constant remembrance of the struggle of novel thought with the obtuseness of language. (Adventures of Ideas 1933/1967 Free Press p120)

⁷ Jaynes, *ibid*

⁸ Ong, *ibid* p29

⁹ AH Maslow (1954), *Motivation and Personality*, Harper, New York.

Colin Wilson (1984), *CG Jung: Lord of the Underworld*, Aquarian Press, Northamptonshire.

¹⁰ Aldous Huxley (1954), *Doors of Perception*, Harper Collins New York.

¹¹ Wilson *ibid* p76

¹² Alan Snyder (1999), 'The genius within', *The Australian*, Nov 12, p 12.

¹³ CD Broad (1925), *The Mind and its Place in Nature*, Routledge & Kegan Paul, London, Chapter 5.

¹⁴ C Wills (1998), *Children of Prometheus: The Accelerating Pace of Human Evolution*, Perseus, Reading. p229.

¹⁵ Merlin Donald (1991), *Origins of the Modern Mind: Three Stages in the Evolution of Culture and Cognition*, Harvard University Press, Cambridge, Mass.

WH Calvin (1997), *How Brains Think: Evolving Intelligence, Then and Now*, Basic Books, New York.