

# ASCAP

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July, 1999

"The more experience and insight I obtain into human nature, the more convinced do I become that the greater portion of a man is purely animal."  
Henry Morton Stanley, 1887

(Quoted in the frontispiece of Crichton, Michael: *Congo*. New York, NY: Ballantine Fiction, 1980)

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**Welcome to MacLean Festschrift participants**  
**Boston, MA July**  
**16-17, 1999**

**Across-Species Comparisons and Psychopathology (ASCAP) Society Executive Council:**

**President:** Mark Erickson  
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Kent G. Bailey-1996-1997  
Daniel R. Wilson -1997-1998

**ASCAP Society Mission Statement:**

The ASCAP Society represents a group of people who view forms of psychopathology in the context of evolutionary biology and who wish to mobilize members and resources of various disciplines so as to enhance the further investigation and study of the conceptual and research questions involved.

This scientific society is concerned with the basic plans of behavior that have evolved over millions of years and that have resulted in psychopathologically related states. We are interested in the integration of various methods of study ranging from cellular processes to individuals in groups.

***The ASCAP Newsletter Aims:***

- ◆ A free exchange of letters, notes, articles, essays or ideas in brief format.
- ◆ Elaboration of others' ideas.
- ◆ Keeping up with productions, events, and other news.
- ◆ Proposals for new initiatives, joint research endeavors, etc.

***The ASCAP Newsletter is a function of the ASCAP Society.***

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**Previous volumes are available**  
For details, contact Russell Gardner, Jr.

**World Psychiatric Association**

**<http://www.wpanet.org>  
for the August, 1999 meeting contact:  
[www.wpa-hamburg.de](http://www.wpa-hamburg.de)**

Some of us will be staying at  
Hotel Holiday Inn, Kieler Strasse 333  
22325 Hamburg, tele 040 54740-0  
fax 040 54740-100

The World Psychiatric Association is an organization of psychiatric societies aimed at advancing psychiatric and mental health education, research, clinical care and public policy.

The basic members of the WPA are 110 national psychiatric societies, representing more than 140,000 psychiatrists worldwide.

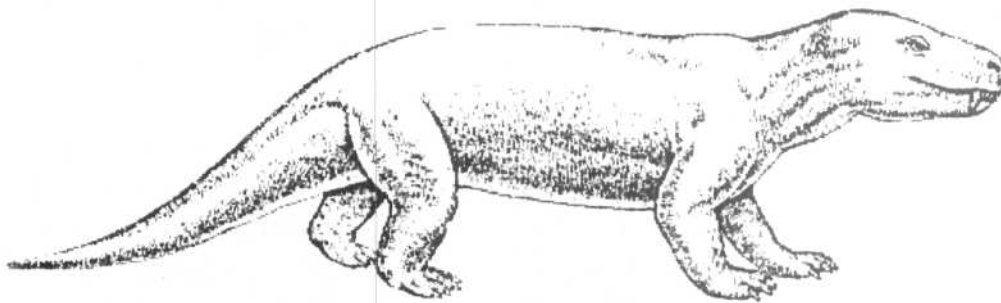


*The ASCAP Newsletter is the official newsletter of the Psychotherapy Section of the World Psychiatric Association.*

Welcome to all participants in the  
Paul D. MacLean Festschrift  
July 16 and 17  
at the Boston BackBay  
Hilton.

As seen in the Table of Contents, this issue with copies of the abstracts within will be your program guide. The overall schedule in its final form resides pp. 6-7;  
author abstracts follow.

The Across-Species Comparisons and Psychopathology (ASCAP) Society is proud to be the sponsoring body of this notable occasion.



Therapsid: reptile-mammal transitional animal. In South Africa, 300 billion fossils beg for study. Paul Maclean urges this research to learn more of early thermoregulation and other adaptations of these ancestors.

### Meeting Announcements

#### WPA Psychotherapy Section Business Meeting Announcement from The Section Chairman

Dear Fellow Psychotherapy  
Section Committee Member:

I have a letter from the Secretary of Sections (Professor Okasha) reminding me that our Section meeting is scheduled for 8.00-10.00 on August 10, 1999, in Hamburg, the exact location to be announced in the final program. Then we are required to elect a chair, co-chair, secretary and four other officers, no more than two being from the same country. In

order for the election to be valid, all our members must be informed of the time and date of the meeting. If there is not a quorum present (one quarter of the voting membership), the officers are required to conduct a postal vote of all members.

I have heard with regret that Jeremy Holmes will not be able to come and be a discussant for the second symposium - this is largely due to the late announcement of the symposium date.

Looking forward to seeing you all in Hamburg.

John Price  
john.price@lycosmail.com

The Cape Cod course has openings still. The topic is **Clinical Sociobiology: Darwinian Feelings & Values**, July 19-23, 1999. Faculty include James Brody, John Price, John Fentress & Russell Gardner. The course focuses on positive features of what has happened from evolutionary forces. Contact James Brody  
jbrody@compuserve.com

#### No Aaron T. Beck ASCAP Award

The Beck Committee chaired by Linda Mealey after considerable deliberation finally agreed that no essay met criteria for the award and that there will be none given this year.

# ADDRESSED TO & FROM...

## Hamburg ASCAP Meeting

Along with President Mark Erickson, general agreement holds that we will go with an informal ASCAP meeting, reverting to the form of the earliest meetings and allowing brainstorming in the more immediate sense, more so even than internet allows. The ASCAP Society will have hosted the MacLean Festschrift in Boston and members will participate in two symposia (see below) at the WPA. Those abstracts that did arrive will go into the August issue.

Where will the ASCAP meeting be exactly? I've been evading this question because at this point I do not yet know. We have made repeated attempts to contact the Holiday Inn but their latest response translates to "contact us on the 1st of July - which is after we send this out). I expect to email and otherwise communicate with all who might come (symposium participants and those who have signaled interest).

In communications with me, Hagop Akiskol has taken our group to task. Hagop is an opinion leader in psychiatry and the co-author (with Bill McKinney) of a classic article in the *Archives of General Psychiatry* in 1973 that laid to rest the distinction between reactive and endogenous depression. He is sold on the importance of the evolutionary roots of psychiatry, having arrived at similar conclu-

sions from his experience. In a very supportive and kind fashion, he asks why, for a revolution that is about to happen, are we not more active and more passionate about a cause that is bound to occur? We have been the leaders, but hardly leading, hardly making any noise? And, he asks, moreover, why are we writing for a publication (meaning the newsletter) that is not indexed for the scientific and medical public?

We should pay heed to him and ask questions: should *The ASCAP Newsletter* do whatever it needs to do so that indeed it is indexed by the National Library of Medicine and other places? Do you know what that is? Should it enlarge, raise money and recruit a larger staff? Should it come out less frequently? It remains a labor of love but consumes time.

Or, maybe it has lived a fruitful life and those now writing for it should instead focus on articles to be read in wide circulation and it should die a quiet death having served its purpose. Yet, is the brainstorming that has been the center of its activity completed? For instance, John Price's novel idea this issue on group splitting as related to messianic but schizoid people is a case in point. No other publication would give it quick publication for group cynosure. Moreover, our section at the WPA needs an organ also. Certainly, your editor will listen to what you have to say.

## WPA Symposia

The symposium chaired by Dr. John Price entitled "Threshold to a Biological Psychotherapy" will be occur on August 8, 1999, from 10:15 am to 12:15 pm. It will be located in Room A of the University Main Building named Edmund-Siemers-Allee. Each lecturer will have 15 minutes and 5 minutes for following discussion.

The symposium chaired by Dr. Russell Gardner, Jr. entitled "The Psychotherapy of Mood Disorders" will take place on August 9, 1999 also from 10:15am to 12:15 pm. This location will be in the Rostock Room of the Radisson SAS Hotel, adjacent to the Congress Centrum.

These symposia and that chaired by Mauricio Cortina were not listed in the WPA website ([www.wpa-hamburg.de](http://www.wpa-hamburg.de)). Because I did not receive any information on the one led by Dr. Cortina, we cannot relay that onto you at this time.

## Origin of Quote

"The things that come to those who wait, may be the things left by those who got there first." This was said by Abraham Lincoln. His advisors told him the time wasn't right for him to run for President and that "good things come to those who wait." Lincoln, saying the above, ran anyway.

Lorraine Rice  
EuterpeL@aol.com

The Evolution of Love  
or Knowing more  
than's good for you.

The modern heirs of Darwin, who never stop for play. Have now thought up a new idea which takes my breath away. It concerns the early humans who shared parental cares By traipsing round the open veldt in tightly bonded pairs.

When it came to picking partners, it was clear to all the rest. It's a basic law of nature that "the better gets the best". No matter how they yearned for her, the fairest naked ape. If she got a better offer, that's the one she'd take.

In terms of evolution this could cause a lot of grief 'Cos pairings made with second best are very often brief. before the days of Welfare this was rather more than sad. As a single mother's prospects were almost always bad.

Then, up there popped a little gene, a very clever chap, Who specified the blue-print for that oh so tender trap. We still peruse the talent with a very steely eye. And still we note, regretfully, that some are placed too high.

But now, once we've made our choice, we forget all those above By letting rip the hormones that will make us fall in love. So though its many mysteries are very widely sung. Love is just a clever trick which helps us raise our young.

But this might lead you to the question: even if it's true. Is this the kind of thinking which you like revealed to you? Perhaps we should tell those guys, if they're very smart. They'll poke and pry some other place and leave alone the heart.

Mike Waller  
mwaller@comparator.win-uk.net

**Festschrift Note: Sad Regrets**

Roger Masters cannot join the Festschrift because he is ill. He will be greatly missed and we wish him the best. His contribution (see Festschrift Abstracts section) symbolizes his pioneering efforts in applying biology to political affairs. He has contributed enormously and

persuasively, e.g., the sometimes mysterious attractiveness of Bill Clinton remains a mystery no longer after reading Roger's research results.

On a personal level, he was an enthusiastic supporter of the Festschrift and helped on many levels throughout its planning.

**Announcement of Book on  
Bullies**

Dr. Jay Carter and I have written a book, and dedicated a web site, to help young people deal with bullies, child violence, and self-esteem. "Taking the Bully by the Horns" is supported by schools, parents, and children's organizations. The web site contains an article I wrote and published using statistics from the American Justice Dept., instructing adults on how to prevent children from becoming a statistic on school grounds. The site also offers "Bully Advice" for kids & young teens.

The American Justice Department says this month 1 out of every 4 kids will experience severe abuse from another youth. IT'S TIME TO DO SOMETHING ABOUT IT!

Would you be interested in purchasing the book for your school/ organization? Also, would you find it appropriate to add my web site as a LINK to your site? Please visit my web site and let me know if you think you might be interested in either.

The URL is:  
<http://members.aol.com/kthynoll/bully.htm> or:  
[http://members.aol.com/\\_ht\\_a/-kthynoll/bully.htm](http://members.aol.com/_ht_a/-kthynoll/bully.htm)

Thank you. I appreciate your interest & support.

Kathy Noll  
(with Dr. Jay Carter  
authors of  
"Taking the Bully by the Horns")  
kthynoll@aol.com

## Detailed Schedule for MacLean Festschrift

Location: Back Bay Hilton in Boston. Make reservations at 800 874-0663 or 617 236-1100 (noting your group affiliation with ASCAP). For non-speakers and people not members of the MacLean family or of the families of the speakers, the registration is \$75 made out to UTMB via check or credit card; prior to the event send to Russell Gardner, Jr. 214 Du Rose Terrace, Suite 1, Madison, WI. 53705

Each presentation allotted 30 minutes with speaker taking 25 or fewer minutes - remaining time for discussion

**Friday, July 16, 1999** (Russell Gardner, Jr., Chairman)

**8:30 to 8:45 a.m. Welcome to and from Dr. MacLean or his family as present**

### Session 1. Neuroscience Perspective

1. 8:45-9:15 C.U.M. Smith: Deep Time and The Brain: Message of the Molecules
2. 9:15-9:45 Gerald A. Cory: Inaccurate Reviews of Paul D. MacLean's 1990 Triune Book
3. 9:45-10:15 Vassilis Koliatsos: The Limbic System Before and After MacLean: Theory, Evidence, and Modern Behavioral Neuroscience

10:15-10:30 a.m. Break

### Session 2. Philosophy, History and Theory

4. 10:30-11 Seymour Itzkoff: Evolutionary and Philosophical Issues of Triarchic Theory
5. 11-11:30 Ernest Barratt & Jeffrey Matthews: MacLean's Triune Brain Model: Historical Perspective
6. 11:30-12 Daniel Levine: Toward a Neural Network Theory of the Triune Brain

12-1:30 p.m. Lunch on your own

### Session 3. Behavior, Emotions, & Children

7. 1:30-2 Neil Greenburg & Robert Switzer: The Beast Within: Human Implications of the Reptilian Brain
8. 2-2:30 Glenn Weisfeld: Human Emotions and Their Ethological Roots: Darwin and MacLean
9. 2:30-3 James C. Harris: Empathy, Compassion, Autism, and the Integration of The Triune Brain

3-3:15 p.m. Break

### Session 4. Aggression & Violence

10. 3:15-3:45 Anneliese Pontius: Neuroethology Exemplified by Limbic Seizures with Motiveless Homicide
11. 3:45-4:15 Daniel Matthews: Practical Results in the Treatment of Violent Youth from Assessing Limbic System Pathophysiology

4:15- 5 p.m. Group and Audience Discussion

6-7:30 p.m. Informal Reception

**Saturday, July 17,1999** (Gerald A. Cory, Jr., Chairman)

**Session 5. Triune Theory and Depression**

- 12. 8:30-9 a.m. John S. Price: The Triune Theory and Depression
  - 13. 9-9:30 Hagop Akiskol: Evolutionary Significance of Hyperthymic and Cyclothymic Temperaments
  - 14. 9:30-10 Leon Sloman: Involuntary Subordinate Strategy as Backdrop for Depression
- 10-10:15 a.m. Break

**Session 6. Triune Theory, Mania and Hyperactivity**

- 15. 10:15-10:45 Daniel R. Wilson: M. Manic-Depression: Triunian Neuroethology, Evolutionary Epidemiology and Hawk-Dove Analysis
  - 16. 10:45-11:15 James Brody: Paleopsychology and Complexity Theory: Mania, ADHD, ODD, Dysthymia and Hierarchic Regulation
  - 17. 11:15-11:45 Alan Swann: on Formulations That Mania Resembles Leadership: Critique and Model
- 12-1:30 p.m. Lunch on your own

**Session 7. Attention and Pathology**

- 18. 1:30-2 Allan Mirsky & Connie C. Duncan: The Triune Brain in Relation to the Functional Analysis of Attention
  - 19. 2:-2:30 Kent Bailey: Upshifting and Downshifting the Triune Brain: Role in Individual & Social Pathology
  - 20. 2:30-3 Horatio Fabrega: On the Limits of an Evolutionary Conception of Psychopathology.
- 3-3:15 p.m. Break

**Session 8. Communication and Implications**

- 21. 3:15-3:45 John D. Newman: Audiovocal Communication and The Triune Brain.
  - 22. 3:45-4:15 Russell Gardner, Jr.: Communicational, Brain and Molecular Basic Plans
  - 23. 4:15-4:45 Karl Pribram: The Adventures of MacLean and Pribram
- 4:45-5 p.m. Audience discussion.



The limbic lobe as a common denominator in mammals from page 247 of *The Triune Brain in Evolution*, 1990  
Rabbit, cat and monkey are here represented.

**For presenters: Chapter Deadline August 30,1999**

# ABSTRACTS for MacLean Festschrift:

Session I. Neuroscience Perspectives

## Paper #1. Deep Time and The Brain: Message of The Molecules

C.U. M. Smith, Ph. D.  
Emeritus Professor  
Vision Science, Ashton University  
Birmingham, UK

**Abstract:** Paul MacLean's brain science has from the first been marked by its evolutionary approach. He also observes in *The Triune Brain* that molecular biology plays a central role in this approach.<sup>1</sup> In the decade since the publication of that summarising book, molecular biology, especially the molecular biology of the brain, has undergone a huge and revelatory development. MacLean quotes with approval from Jacob's well-known essay 'Evolution and Tinkering'<sup>2</sup> and the molecular history of the brain falls very much under that heading. Molecular motifs recur time after time, sometimes apparently re-invented, more often originals adapted to new and unexpected roles. Evolution works with what it has to hand, tweaking and bending it in novel and surprising ways. It has no opportunity to go back to the beginning and start afresh. This, at the molecular level, is very much what MacLean argues to have occurred, at the macroscopic level, for the entire brain.

In this contribution I shall review some of the salient features of these developments in molecular neurobiology insofar as they shed light on the evolutionary history of the human brain. This takes us deep into past time. I shall start by discussing the extraordinary ubiquity of the 7TM 'serpentine' motif in both sensory cell and synaptic membranes. This motif first appears amongst the prokaryotes. It is, for instance, well known to be concentrated in the purple membrane of halophilic bacteria where it is known as bacteriorhodopsin. As this group of bacteria are members of the oldest prokaryote kingdom, the Archaeobacteria, we can presumably trace the 7TM

motif back more than two and half thousand million years. The motif re-appears in animal chemoreceptors and photoreceptors and, indeed, in other types of receptor as well as in numerous ligand-gated synaptic receptors. Has it been re-invented or merely revised? There is evidence for both processes. It has been 'tweaked' to play numerous different roles.

Another fascinating evolutionary story is provided by the molecular structures of voltage and ligand gated ion channels. Do they all derive from prokaryotic stretch detectors? Again the origin, if this is the case, takes us back deep into past time. Early on, an evolutionary line led to ion channels sensitive to transmembrane voltage and hence to the possibility of signalling by way of action potentials. Later, another evolutionary line led to ion channels coming under the influence of various chemical ligands. In recent evolutionary history there has been a remarkable 'efflorescence' of these ligand-gated ion channels in the more complex brains of 'higher' vertebrates. Does this comparatively recent increase in diversity underlie the increased information processing capacity of mammalian brains? Then, to follow the stretch-detector story in another direction, we can note how the extraordinarily sophisticated mechanoreceptors of vertebrate auditory hair cells are built around simple mechanoreceptor designs which are to be found as far down the evolutionary tree as the nematode worms. Once again, a molecular solution once found, is used and elaborated in a multitude of different ways.

Finally, I shall touch on some of the fascinating findings of the early molecular embryology of brains and sensory systems: that the genes controlling the early development of vertebrate eyes are also to be found in cephalopods and can induce the development of ectopic eyes (insect eyes, of course) in *Drosophila* is only one of the many thought-provoking findings reported in the literature. Human and animal brains are netted together deep into the past in ways hardly imagined only a few decades ago. MacLean's pioneering vision of the evolutionary interconnections of the



human brain with those of our fellow animals is amply confirmed.

1. MacLean PD: *The Triune Brain in Evolution*, New York: Plenum, 1990, p.13

(2) Jacob F: Evolution and tinkering, *Science*, 1977;196:1161-1166

## Paper #2. **MacLean's Triune Brain Concept: In Praise And Appraisal**

Gerald A. Cory, Jr., Ph.D.  
The Center for Behavioral Ecology  
San Jose, CA 95110  
Copyright 1997

**Abstract:** Paul D. MacLean is a trailblazer in neuro-science as well as a humanist deeply concerned with the larger questions of human life. His triune brain concept has been called the single most influential idea in neuroscience since World War II. It has been well received in medicine, education, and with the lay public. In some quarters of neuroscience, however, it has been criticized as outdated, erroneous, and of no impact within the discipline of neuroscience itself. Following the publication of his 1990 opus, *The Triune Brain in Evolution*, MacLean received highly critical reviews in two prominent science periodicals, *Science* and *American Scientist*. Both reviews were written by neurobiologists and both reviewers claimed that MacLean's triune brain concept has had limited acceptance or been largely ignored by professional neurobiologists. This paper examines the criticisms made by these reviews, with special emphasis on the influential review that appeared in *Science*, and finds them not only displaying serious deficits in scholarship, but also containing gross errors, inaccuracies, and misrepresentations of MacLean's highly documented and sophisticated work. The review in *Science* is so prejudicial and careless that, in the author's opinion, it raises a serious question of professional standards if not ethics. Other reviewers seem to have relied uncritically on this review and parroted unreflectively the same errors, inaccuracies and misrepresentations. After reviewing and appraising the criticisms, this paper concludes that the triune brain

concept is soundly grounded in evolutionary neuroscience and, with some clarifications, is the most useful concept we have for linking neuroscience with the larger, more highly generalized concepts of the social sciences. With its focus on subjective experience it also has relevance for the emerging study of phenomenal issues of consciousness, and more importantly, for the crucial social and political issues of moral consciousness.

## Paper #3. **The Limbic System Before and After MacLean: Theory, Evidence, and Modern Behavioral Neuroscience**

Vassilis E. Koliatsos, M.D.  
Departments of Pathology (Neuropathology)  
Neurology  
Neuroscience &  
Psychiatry & Behavioral Sciences  
Johns Hopkins University School of Medicine  
Baltimore, MD

**Abstract:** The notion for a "limbic" system and related concepts, like MacLean's "triune brain" have been great inspirational themes for much of contemporary behavioral neuroscience. Broca's "grand lobe limbique" (the great lobe in the border) was a comparative notion for an apparent across-species stability of a certain portion of the mesial structure of the hemisphere which was arbitrarily, if not superficially, separated from the rest of the brain.

Papez declared this arbitrary notion as the long-sought site of obligatory emotional processing, thus constructing a heavy doctrine which was arguably "at the border" of scientific testability. MacLean's historical contribution was not to validate the identity, but rather to defend the operational importance of the limbic construct by showing the behavioral significance of the cingulate subdivision of the limbic lobe and by further strengthening the explanatory power of the construct with evolutionary and clinical ideas culminating to his "triune brain". In a scientific lineage punctuated by the Jacksonian notions of "higher" and "lower" centers and the idea of "release" and the Freudian conflicts between the id and the ego, these all-encompassing

ideas provided a neurobiological forum for debates and integration of ideas originating in basic and clinical observations and spanning from psychoanalysis to neurophysiology. The "limbic system" and the "triune brain", grand themes as they are, have never been directly proven as scientific truisms and, in fact, recently generated data have denied their universal application. However, the heuristic importance of these concepts for contemporary behavioral neuroscience and the impetus they provided for much extraordinary research has made them indispensable structures in our thinking about the brain, part of the lexicon of modern neuroscience.

The productive and most relevant line of research on the role of the medial temporal lobe on certain types of declarative memory and the extraordinary work on the role of amygdala in fear conditioning and emotional recognition are testimonial to the inspirational role of the concept of a limbic system. Most recent studies using positron emission tomography for identifying brain structures involved in the processing of anxiety, central perception of pain, dreaming, impulsivity/compulsiveness and certain states of mood have highlighted areas clustered in cortical areas around hippocampus and piriform cortex, the so-called paralimbic zone.

Patients with temporal lobe epilepsy continue to provide important, if not at times baffling, clues about affect regulation and integration of emotions with other aspects of mental life. Most important of all, recent experiments on the structural impact of stress on medial temporal structures processing recent/episodic memory, such as the hippocampus and accumulating evidence of hippocampal injury in certain patients with post-traumatic stress disorder (PTSD) provide a definitive vindication of the limbic concept and its integrative power.

This evidence from PTSD patients and animal models highlights the unitary nature of phenomena arbitrarily divided as mental versus neurological or cognitive versus emotional and suggests that the hippocampus - together with the associated caudal-ventral portion of the paralimbic zone - may function as the brain integrative sensors for the extrapersonal space (much

like, on the other end of the limbic system, hypothalamus and related brain stem areas are the central sensors of the internal milieu).

All the above lines of investigation illustrate the realism of MacLean's request for a science of subjective experience ("epistemics"). In an era featured by an overwhelming devotion to molecular science, these investigations also remind us that, to advance our understanding of our brain, we need brilliant hypotheses based on the broadest possible knowledge of systems and a continued commitment to the few fundamental questions pertaining to human nature and human misery.

## Session 2. Philosophy, History and Theory

### Paper #4. Evolutionary and Philosophical Issues of Triarchic Theory

Seymour Itzkoff  
Emeritus Professor, Smith College  
Northampton, MA, USA

"The focus of the present book will be on protoreptilian and paleomammalian formations and their role in nonverbal aspects of behavior and mentation." *The Triune Brain in Evolution*, p. 10

**Abstract:** MacLean endeavors to show that human behavior is composed of neurological structures inherited from our ancient reptilian and mammalian ancestors. In this he is close to contemporary socio-biological thinking. As such he is a trailblazer in his attempt to link human behavior with the varying phylogenetic structures that are part of our evolutionary inheritance. In this neuro-architectural endeavor, MacLean is even more of a pioneer. He details with chapter and verse the morphologies and contemporary structural interactions inherited from this reptilian and mammalian base. Naturally he is concerned to make the connection with the neopallium and modern human isocortical structures and behaviors.

Even given MacLean's recognition of the crucial role of causal thinking in the powerfully selective rise of humans to dominance as well as his acceptance of

the role of language in coordinating the higher integrative conceptual powers of modern humans, it is still the paleoneurological substrate that interests him in his unraveling of the evolutionary heritages that underlie all human behavior

MacLean is committed to the task of showing a line of continuity between the development of each new tetrapod neuromorphological structure as it evolves, concomitantly with the Darwinian behavioral enhancements that reflect this shift. Yet in the end, it is this continuity, even dominance of the past over the present that seems central in MacLean's analytical and evolutionary drama.

The basic thrust of MacLean's interpretation places human functioning at the causal beck and call of these so-called triarchic sets of brain and neurological structures. The evolutionist is enjoined to view the behavioral power of the r-(striatal) complex and the limbic system as central to the adaptive and selective destiny of the line leading to humans. The dimensions of inductive thought, prediction, anticipation, organization, and assimilation of perception through memory, seem to fade in critical mass when compared to the evidence of the modern reification of more ancient brain and neurologically rooted behavioral patterns.

In an important development of the implications of MacLean's theory, two scholars at the University of Palermo, Italy, M. Emandes and S. Giammanco, probe the powers of the r-complex and the limbic system in order to clarify human hierarchical social institutions, both religious and political. In concordance with MacLean, the r-complex fixes connections among phenomena- temporal -momentary; conformity or non-conformity with precedent conditions; ritualistic changes in behavior. The limbic system adds an emotional element, producing relaxation when activities are completed, anxiety when they are brusquely interrupted or changed. The neocortex has "induction" capacity from particular phenomena, that there are causal connections in all perceptual experience. In humans, r-complex factors lead to obsessional and magical behavior, compulsions; a language

factor is added to these r-complex elements. Although inhibited by the limbic system, the human brain's r-complex preserves the structures and hierarchy-forming functions that give rise to submission to leaders. MacLean sees "the immensely powerful being" as being created by the action of the r-complex on the neocortex. Emandes and Giammanco see a weakening over the span of human evolution of the inhibitory influence of the limbic system on the r-complex's power over the neocortex.

The argument of this chapter, in contrast to the above analysis, holds the freedom of humans to choose, to think, to create, to advance or to retrogress, constitute inherent powers at the highest levels of human cortical intelligence. In earlier forms of *Homo*, whose cultures barely changed over thousands of generations, the r-complex and the limbic system may have been in stagnant balance, even manifesting behavioral precedence over the cortex; comparative brain size and structure hint at this probability. By contrast, the morphological, neurological and behavioral revolution hinted at in the more recent hyper-extended neocortex of *Homo sapiens sapiens* (*Hss*) speaks loudly to this morpho/behavioral evolutionary transition. The unique taxonomic position of our sub-species in the evolving phylogeny of the vertebrate/mammal/primate that became *Hss*, perhaps no more than 125,000 years ago, has been revealed to us for a bare 45,000 years.

The philosophical question that obtrudes from triarchic theory stems from our contemporary interest and involvement in motivated behaviors derived from r-complex and limbic system imperatives. Is this recent preoccupation with and surrender to the reptilian and mammalian dimensions of human behavior a reflection of a conscious or predetermined regression in the course of human evolution? Is what we have experienced in the 20<sup>th</sup> century - genocide, social irrationalism, psychodynamic pathology-a product of the general weakening in the human species of its ability to fulfill its potential for civilizational life revealed to us as a possibility by the cortical intellectual achievements of Cro-Magnon 45,000 years ago?

Paper #5. **MacLean's Triune Brain Model: Historical Perspective**

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**Abstract:** Paul MacLean made significant contributions to the advancement of the neural sciences at a time when classical neuroanatomy was merging with classical neurophysiology, psychopharmacology, and experimental psychology to become the discipline of cognitive neuroscience. His contributions to understanding the neural substrates of human behavior were not only multidisciplinary in nature but also somewhat unique in his blending of the more traditional sciences with ethology. Beyond this blending, his research was rather typical of other experimental approaches to studying behavior during his active research years. Techniques which he used included: 1) brain stimulation, lesions and ablations; 2) histo-logical preparations of brain tissue; 3) comparative anatomy; 4) comparative behavior. He used the techniques of his era well and attended to details. His papers provide the details necessary to replicate his research and defend his conclusions, the latter not always being universally accepted. One could disagree with his conclusions but in general not his data.

At a conceptual level, MacLean anticipated the development of cognitive neural science. The many constructs which he developed as bases for guiding his experiments and drawing inferences from his data would fit in well philosophically with current cognitive neuroscience. The best known of his constructs was the triune brain, an ethological model of the human brain and cognition. He proposed that the human forebrain has three divisions which "anatomically and biochemically reflect an ancestral relationship, respectfully to reptiles, early mammals, and late mammals." MacLean was explicit in proposing these mentalities as characteristic to human cognition. His tripartite brain model was the cornerstone of his

approach to the "meaning of life."

Other constructs which MacLean proposed in an effort to support his triune brain model included the R-complex, prosematic communication, epistemics, and paleomentation. It is not uncommon for researchers to create or borrow terms for constructs within their theoretical formulations to *signal* that their theory is unique. Well known examples of this use of symbolism were the writings of Sigmund Freud and Raymond Cattell. Both labeled personality constructs using Greek and Latin symbols. The usual motivation for this use of new terminology is two-fold: 1) to brand the model or theory as "different" from existing theories; 2) to avoid the built-in biases and connotations that existing terms carry with them. The latter was MacLean's goal. However, using new symbolism runs the risk of a general lack of acceptance of the constructs or even knowledge of the constructs by other researchers and this appears to be what happened with MacLean's models. One finds few references in the current literature on emotions, cognition and personality theory to the triune brain, prosematic behavior, epistemics, or the R-complex, yet these were the basic concepts around which this theory was constructed.

MacLean's triune brain construct was formulated at a time when logical positivism still had a dominant role in the mental and behavioral sciences. Physics had provided the scientific model for research and behavior-ists wanted to emulate the physicists' method and achieve their "objectivity." MacLean questioned this allegiance to objectivity in general in science and especially questioned it for the "psychological and brain related" sciences. Briefly, he proposed a new field of knowledge that would be "fundamental" to the psychological and brain sciences," but that would draw on all branches of science to study the relationship of the external and internal worlds. He suggested the body of knowledge resulting from this endeavor be labeled "epistemics," the Greek word related to epistemology. He noted that the two terms are the same in meaning but there is a difference in "point of view," consistent with the earlier observation that he attempted to avoid biases in terminology by creating new terms for his theorizing. Beyond that motive,

however, it is clear as also noted that he anticipated what is currently known as the cognitive neuro-sciences. Although his current writings appear to be more directed at the interface of cognition and biology, he certainly indicated in his earliest writings that his goal was to bridge Cartesian dualism consistent with a broad range of interdisciplinary research.

The triune brain as noted referred to three "compartments" of the brain which MacLean proposed reflected the evolutionary development of the brain. Although MacLean insisted that these were not meant to be "watertight" compartments and that they interacted with each other, he did propose that conscious and unconscious awareness and verbal and non-verbal communication were related in different ways to these three brain systems. From an evolutionary viewpoint, a key period in his view was when the "protoreptilian formations of brain" were formed. This collection of ganglia located at the base of the forebrain in reptiles, birds, mammals he labeled the "R-complex." The importance which he attached to it shows from his observation that "R-complex is as much the bedrock of the forebrain as the Laurentian Shield is to the North American Continent." The structures contained in the R-complex included parts of the basal ganglia which have traditionally been considered "motor" centers. Because of his belief that the R-complex was crucial to a wide range of human behavior, he spent much research time studying reptilian behavior at the NIMH Laboratory of Brain Evolution and Behavior which he founded and guided for many years. His research demonstrated that components of the R-complex were not involved exclusively with motor functions, consistent with current thinking. The other two components of the triune brain included the limbic system (paleomammalian formation) and the neo-cortex and thalamic structures (neomammalian formation). Again conscious awareness and communication were related to the interconnection of these structures with the R-complex, especially non-verbal communication which he labeled "prosematic" communication. The latter includes in lower animals as well as humans a wide range of "display and posturing" behaviors which relate to dominance, aggression, and mental disorders in MacLean's theory.

Three questions to be addressed in evaluating the historical significance of MacLean's model and theories are: 1) what is the current status of the theory? 2) did the theory have a lasting impact on science? and 3) are there lessons to be learned from his research? These will be addressed at length in the ensuing manuscript.



Paper #6. **Toward a Neural Network Theory of the Triune Brain**

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Abstract: Previous mathematical results of Grossberg and Levine have dealt with a neural network composed of neuron populations representing different features competing and cooperating for short-term memory storage. Grossberg and Levine showed that if the network is subject to constant attentional biases, it still approaches an equilibrium state representing stable short-term pattern storage. But what if there are two sets of attentional biases and they vary over time? That represents a possible simplified network representation of Cory's version of MacLean's triune brain theory. One set of biases represent the claims of self-interest, whereas another set of biases represents the claims of reciprocity. Some preliminary simulations have explored a network whereby each set of biases takes over if the network has reached a state of "overbalance" toward the other set of biases. The results hint that such a network can in certain parameter ranges exhibit chaotic behavior which might be indicative of some human cognitive dissonance phenomena.

### Session #3. Behavior, Emotions, & Empathy

#### Paper #7. The Beast Within: Human Implications of the Reptilian Brain

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**Abstract:** Paul MacLean correctly perceived that evolution of brain (like all evolution) depends on selective feedback from the environment reflecting the success in meeting adaptive needs. Evolved neural structures are often associated with taxa that symbolize the predominant function therein coordinated. Of course neural structures continue to evolve after the initial innovation that provided an advantage in its initializing environment of evolutionary adaptiveness. Neural structures build on their unique qualities by a process akin to bricolage, and while structural details such as proportion may change, organizational details provide powerful clues about the causes and consequences of brain evolution. Since the striatum-based R-complex was proposed, additional information has been forthcoming about the respective roles of basal and frontal forebrain in the integration of cognitive, motivational, and affective, neurobehavioral mechanisms. The insights of the evolutionary process of ritualization in concert with recent ideas about mechanisms of brain evolution converge to provide a broader view more conducive to generating testable hypotheses.

#### Paper #8 Empathy, Compassion, Autism, and the Integration Of The Triune Brain

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**Abstract:** Those species with the most highly evolved brains have the greatest brain weight, show the greatest social cooperation, and are the most so-

ciable. This suggests that brain evolution is moving toward greater sociability, a position taken by the Russian evolutionist, Kropotkin, who emphasized "mutual aid" as the driving force in evolution rather than "survival of the fittest."<sup>1</sup> Mutual Aid among members of a species has been proposed as the most potent force in evolution.

Paul MacLean's work on the integrated function of the triune brain supports this emphasis in evolutionary theory. The evolutionary steps toward sociability have been championed by him in his studies of the effects of brain lesions on behavior in lizards, rodents and monkeys (*anolis carolinus*, squirrel monkeys, and other species). He discusses an increase in sociability and social responsiveness that emerges with particular evolutionary advances in social behavior, as we move from reptiles to primates. Most striking are those evolutionary changes that lead to cooperation in family life. Indeed it has been proposed that consciousness may have its rudimentary beginnings with affective arousal directed toward the feeding of the young.<sup>2</sup> Advances in sociability emerge as the mother develops the capacity to attend to the infant's cry, nurse her infant, and provide a safe environment for mastery play. In primates eye to eye contact with the young and the capacity to grieve the loss of conspecifics emerges and is found in chimpanzees. In *Homo Sapiens*, not only grief, but also expressive gestures of comfort toward the bereaved make their appearance in evolution. Yet in some neurodevelopmental disorders such as autism, there is a failure in these basic mechanism leading to sociability.

The steps of in the establishment of social life linked to the separation cry, maternal care, and play have received increased support in the work of the ethologists, neuroethologists, psychologists and psychiatrists in studies of attachment, hierarchies of relationships, affective modulation, working models of relationships, and response to novelty have been studied. The child development literature is beginning to trace the emergence of mother/infant attunement and attachment, the physiology of the separation response, and the biology of play. The role of the REM sleep in the consolidation of memory and in subsequent adaptive responses is also being considered.

Essential to the integration of the triune brain in primates is MacLean's recognition that when the "cold sense" of vision (cortex) is linked to positive affective regard (limbic brain), it is possible to "look with feeling", i.e. to be empathetic toward others. With the integration of empathetic affect with reflective consciousness compassion towards others becomes possible. It is proposed here that in spontaneous acts of compassion the triune brain is functioning in its most integrated manner.

The metaphor of the integration of the triune brain may be considered a basis for psychotherapy as the therapist looks for spontaneous acts of integrated functioning. One goal of psychotherapy is to reduce self deception in relationships with others and, in so doing, to become empathetic and demonstrate compassion towards others. This linking of affect and cognition is basic to psychotherapy - an interperson-ally attuned approach to therapy that deals with the minute particularities of those moment of therapeutic contact between therapist and patient. This encounter provides an opportunity for empathetic understanding and as a result changes in behavior. MacLean's emphasis on epistemics, subjective understanding, is particularly important for psychotherapy where understanding self-deception and deceptive behavior towards others is most pertinent. Indeed it may be that the goal of psychotherapy is to realize, confront, and confirm the effects of self-deception on oneself and others.

The failure of the integrated function of the triune brain is most evident in those neurodevelopmental disorders, such as autistic disorder where MacLean's hypotheses about the integrated function of the triune brain can be investigated. In autistic disorder, failure of the development of limbic structures (amygdala, hippocampus) and cerebellum may result in a failure in empathy.<sup>3</sup> Autistic disorder exhibits a lack of social referencing, failure in affective attunement, and in the establishment of a sense of "We-ness", the subjective sense that we are doing something together. The failure of integrated social functioning and appropriate use of social gestures will be a subject of this presentation. It leads the evolutionary oriented psychiatrist to

consider how we can profitably study brain mechanisms involved in interpersonal relationships, the linkage of executive function with emotion regulation, emotional memory consolidation in REM sleep, and mastery play in children and adults to develop a model for the integration of the triune brain.

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## Session 4. Aggression and Violence

### Paper 10. **Neuroethology Exemplified by Limbic Seizures with Motiveless Homicide**

By Anneliese A. Pontius  
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**Abstract:** Paul MacLean's evolutionary model, hierarchical model of the organization of the human brain has paved for me the way toward insights into otherwise unexplainable clinical phenomena. His model provides a basis for conceptualizing sudden, brief atavistically regressive acts during partial nonconvulsive seizures starting in the evolutionary old limbic system. Secondly, such seizures appear to briefly upset the normal fronto-limbic balance. Thus, the reciprocally related, evolutionarily young frontal lobe system becomes transiently dysfunctional. Over two decades of clinical forensic studies, MacLean's model enabled me to propose a transient "Limbic Psychotic Trigger Reaction" (LPTR) consisting of 13 specifically interrelated symptoms and signs. These implicate the neurophysiological mechanism of limbic seizure kindling.

The symptomatology has been delineated in the following: atavistically regressive acts accompanied

by autonomic arousal and a brief *de novo* psychosis. Such apparent behavioral seizures are associated with out-of-character motiveless, unplanned acts of sudden onset and cessation, committed with flat affect, typically against a stranger who happened to provide an individualized stimulus that revived a memory of past intermittent mild to moderate stresses (a setting characteristic of limbic seizure kindling). The symptomatology reflects three seizure-related phases (aura, ictus, post-ictus) with preserved consciousness and memory of the puzzling acts of homicide (17 cases), destruction by fire (3 cases), and primitive, acquisitional "bankrobbery" (1 case). Eleven of the 21 cases of LPTR had a known history of closed head injury and 14 of the 21 had some positive finding on a brain test in their lifetimes.

**Paper # 11: Practical Results in the Treatment of Violent Youth from Assessing Limbic System Pathophysiology**

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**Abstract:** Pathologically aggressive behavior has been shown to be an individual trait that is quite stable overtime, and to have a poor long-term outcome in numerous studies published in the psychiatric and correctional literature. These studies did not, however, differentiate between premeditated and impulsive aggression. According to Barratt, impulsive aggression includes rage attacks that occur without apparent provocation, without premeditation and with no apparent gain. Once an attack begins, an agitated state persists for minutes to hours, after which there is poor recall for the episode.



Over the past ten years we have evaluated over three thousand patients who met Barrett's criteria for impulsive aggression utilizing long latency (500 millisecond) auditory, visual and P-300 evoked res-

ponse testing. Approximately 85% had aberrant and/or excessive electrophysiologic responses occurring between 100-250 milliseconds on visual evoked response testing and between 150-300 milliseconds on auditory evoked response testing. Over 50% also had an absent P-300 response.

Although there is some dispute, there is a body of literature based on depth electrode and magnetoencephalogram studies indicating that the generator sites for this portion of the wave forms are within the limbic system (i.e.; hippocampus, amygdala and internal temporal lobe). This strong correlation between explosive impulsive aggression and electrophysiologic abnormalities in the temporolimbic system has led us to propose a Limbic Dysmodulation Syndrome to be the anlage of this subtype of pathological aggression.

Since carbamazepine has been demonstrated to be effective in amygdala kindled seizures, we chose to utilize it to treat the episodic explosive aggression. Within two weeks of achieving a consistent blood level of 10-12 micrograms/milliliter, over 90% of patients experience no further explosive episodes. This success rate has remained consistent in ensuing one and two year follow-up studies. But if the blood level drops below 10 meg/mil., 86% experience a return of episodic explosive aggression with 71% requiring rehospitalization due to the severity of their aggression.

**Session 5. Triune Theory and Depression**

**Paper 12. The Triune Theory and Depression.**

John S. Price, D. M.  
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Odintune, Sussex, UK

**Abstract:** Paul MacLean described three "central processing assemblies" in the neomammalian, paleomammalian and reptilian brains which make decisions about responses to environmental change relatively independently. It may be useful to apply this model to the vertebrate "agonistic strategy set" which



contains the two alternative strategies of escalation (fight) and de-escalation (escape or submission). At the neomammalian level there is a conscious, rational decision either to fight or give in. At the paleomammalian level, which relates to the emotional brain and the limbic system, there is deployment of either the escalatory emotions of anger, exhilaration, blood lust, blind rage, *etc.*, or of the de-escalating emotions of fear, depression, shame, guilt, *etc.* Usually a decision to fight is associated with warlike emotions, whereas a decision to give in is associated with a feeling of being chastened, but in some cases the two levels may adopt incompatible strategies: one may decide to fight and yet be paralysed by fear.

We have suggested that, at the reptilian level of the forebrain, the escalating strategy consists of elevated mood and the de-escalating strategy consists of depressed mood (depressed mood is unfocused or self-focused, whereas depressed emotion is focused on an object, and is affected by a change in the circumstances of that object). Normally, the pessimistic thinking induced by depressed mood is sufficient to ensure that a de-escalating strategy is adopted by the neomammalian brain, but sometimes, due to pride, stubbornness or uncontrollable circumstances, the neomammalian brain continues to escalate while the reptilian brain continues to de-escalate; this leads to a condition which we may recognise clinically as depressive illness.

Stevens A, Price JS: *Evolutionary Psychiatry: A New Beginning*. London and New York: Routledge, 1996

### Paper #13. The Evolutionary Significance Of Temperament: Focus On Cyclothymic And Hyperthymic Types

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**Abstract:** Bipolar disorders, like anxiety disorders, represent excellent opportunities to conceptualize the link between mental disorders and temperamental attributes. Temperament refers to stable behavior

traits with strong affective coloring. Current evidence suggests that bipolarity lies along a continuum from extreme temperament to full-blown affective illness.<sup>1</sup> Less work has been conducted on the continuum between normal and extreme temperaments, but whatever data is available does suggest that most temperamental traits are continuously distributed. Although the link between temperament and mental disorder goes back to the earliest days of psychological medicine in the Greek period, it is not presently part of the orthodox body of psychological and psychiatric science.<sup>2</sup> Nonetheless, since at least the work of Kraepelin, many authorities have hypothesized a continuum between cyclothymia and full-blown manic depressive illness. Kretschmer expressed it most eloquently when he stated that "endogenous psychoses are nothing but exaggerated forms of normal temperament."

Within this theoretical framework, this paper presents work conducted by the author that supports the fundamental role of temperament in the predisposition to affective disorder and affective psychoses. Those who oppose this view question why normally distributed traits should underlie a major mental aberration. The question could be more meaningfully examined from the reverse position. The author submits that the affective temperaments represent the most prevalent phenotypic expression of the genes underlying bipolar disorder. The disorder itself is an aberration and exists simply because the genes themselves, likely to conform to polygenic models, are useful for evolutionary ends and, in principle, should be demonstrable in other species. Depressive traits, among other functions, would subserve sensitivity to the suffering of other members of the species, while generalized anxiety temperamentally would subserve altruistic worries; it would not be farfetched to suggest that such traits would enhance kin survival and, by proxy, one's own genome. Cyclothymic traits, with their capriciousness, would make the subject more difficult to attain for lovemaking, thereby assuring that the most robust spouse could be found, who would assure better survival of offspring emerging from such unions. Hyperthymic traits would lend distinct advantages in exploration, territory, leadership, and mating. These are just some of the possibilities of the rich and complex temperamental traits within an evolutionary

framework.

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3. Akiskal HS: Toward a definition of generalized anxiety disorder as an anxious temperament type. *Acta Psychiatr Scand* 1998;98(Suppl 393):66-73.

**Paper #14. Involuntary Subordinate Strategy as Backdrop for Depression.**

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**Abstract:** The social competition model of depression clarifies the evolutionary and communicative function of subordinate mechanisms that contribute to the psychological and biological features of depression. This model has provided testable predictions for a number of research studies. It has also proven highly relevant in formulating the psychodynamics of depressed individuals and dysfunctional family interactions and in devising appropriate psychotherapeutic interventions. By integrating this model with other models like attachment theory, discrete emotion theory and cognitive behavior therapy, it can be viewed as part of a broader, more comprehensive model of family interaction while also providing a clearer formulation of how these interactions effect the individual's affect and cognitions. Within this context, variations in self-esteem and mood fluctuations reflect the operation of genetically programmed mechanisms with an important adaptive function. A psychotherapeutic case example will be provided.



**Session 6. Triune Theory, Mania and Hyperactivity**

**Paper 15. Manic-Depression: Triunian Neuroethology, Evolutionary Epidemiology and Hawk-Dove Analysis**

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**Abstract:** Maclean, elaborating on the earlier ideas of Broca and Papez, has given us the classic account of reptilian behaviour. In *The Triune Brain in Evolution*, sombre reptilian algorithms ('RAB' & 'RHP') are noted to yet reside amid more cozy mammalian complexes such as thermoregulation, motherhood, parentalism, pair-bonding, kin selection, play and eusocial affiliation.

Vertebrate brains have an analogue of self-esteem with neuromentalities raised or lowered by signals from conspecifics.<sup>1</sup> Such signals entail reliance on an apparatus phylogenetically quite old and deeply rooted in those genomic elements which organise behaviour. While this apparatus greatly elaborated in subsequent mammalian and primate evolution, multiple authors have noted that changes have often come to overlay but not wholly replace earlier features.<sup>2</sup> Hence, conceptualisations of human neuromental phenomena must account not only for reptilian origins but also ongoing retentions. Retentions were modified in the course of integration with newer primatomammalian neuromentalities, e.g., the later limbic, cortical, neo-cortical tissues (and neuroendocrine innovations). However, phylogenetically old adaptations can be operationally released in certain, often pathological, circumstances; as when functional tensions arise between R-complex and upper cortical operations, usefully termed "phylogenetic regression" by Bailey, including mania and depression.<sup>3</sup>

It is, however, especially revealing to explore the convergence of MacLean's concepts with another potent model in behavioral evolution: game theoretic darwinism. Here competition stratifies populations in

terms of reproductive fitness in each generation within each species. Game theory models two alternatives in social competition: escalation, Hawk, or de-escalation, and Dove (evolutionary stabilised strategies (ESS)).<sup>4</sup> Variations on these strategies appear to be part of what defines either an entire species genome, or a polymorphism therein. The Hawk-Dove ESS exemplifies deeply canalised, successive and genetically polymorphic triune neuromentalities that are entirely compatible with both the basic and clinical sciences germane to the theory and clinical management of manic-depression.

This paper attempts to reconcile manic-depression with triune neuroethology via a brief review of both manic-depression and the triune brain with respect to (1) relevant evolutionary epidemiology, and (2) consilience with game theoretic models.

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2. Bucy P, Kluver H: An anatomic investigation of the temporal lobe in the monkey (*Mucaca mulatta*). *J. Comp. Neurol.* 1955; 103:151-252.
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4. Maynard Smith J: *Evolutionary Genetics*. Oxford University Press, Oxford, 1989.

**Paper 16. Paleopsychology and Complexity Theory: Mania, ADHD, ODD, Dysthymia and Hierarchic Regulation**

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**Abstract:** Ideas from evolutionary theory and complexity theory have synergistic relevance to alliances and hierarchies and to four derivative clinical syndromes — mania, oppositional defiant disorder (ODD), attention deficit hyperactivity disorder (ADHD), and dysthymia. These "externalizing disorders" reflect dissonance between our striatal "go" origins and our

newer refinements for social regulation and response inhibition.

An alliance increases the range of traits that are available to any member but slows decisions by the participants. Larger alliances lead to slower decisions than smaller ones. Hierarchy simplifies information swaps between members of the group for the jobs of acquiring food and mates, defending boundaries, removing waste, and defending self interest whether against predators, competitors, and pathogens or against peers, mates and offspring. Because hierarchies form so quickly, decision latencies do not erupt when the group increases in size. Hierarchy allows self interest to operate within a group context. The negotiation between self interest and reciprocity is vital in alliances and hierarchies and can lead to survival and reproductive failure if handled badly, to contentment and sturdy children if handled well.

Concepts of fitness, natural selection, and sexual selection are relevant. "Fitness" allows some understanding of linear hierarchies while executive functions are key tools that manage reciprocity with peers and with our physical niches. High activity level along with enhanced performance accuracy and other traits (higher I.Q. and vocabulary) appear to be maintained by sexual selection, promoting long term species survival by regenerating behavioral variability. High activity level is one component of fitness but may be dissociated from the other components in disorders such as ADHD.

An introduction to Kauffman's triphasic model will be given in order to analyze mania, ADHD, and dysthymia in a broader context than previously attempted. Kauffman's model — paraphrased here as "paralysis-flexibility-stereotypy"— evolved as a dynamic summary of genetic actions; because it is a decision model with mathematical foundation, it also likely applies to our social groups and our individual behavioral excesses.

"Executive functions" (also called "algorithms") correspond to Kauffman's "flexibility" (phase transition) range and the concept helps us to distinguish mania from ADHD and dysthymia from the other depres-

sions. Executive functions consist of working memory, word retrieval, thought sequencing, time sense, generation of plans, sharing of plans, reflection on outcomes, affect inhibition or kindling, problem analysis, and problem solution. This phase is associated with decisions that occur relatively quickly but more tentatively as we change our minds in response to more subtle feedback.

Mania, generally associated with fitness, is inconsistent with a "simple fitness" model wherein a little mania is good for us and a lot of it is better. Mania is aggravating in particular niches and in combination with other assets of the carrier. Excessive grandiosity (a severing of reciprocal ties with peers) puts mania near the "stereotypy" segment of Kauffman's model and is associated with heightened individual variability and independent action. By definition, the severing of influence by consequences and from other people (grandiosity) is a larger social irritant than a high activity level.

ADHD is handicapped not by activity level (an asset) but through lapses in executive functions (a liability). ADHD, like mania, is characterized by heightened variability in personal behavior but is more reactive and error prone. In contrast, mania — to the extent that executive functions are intact — has exceptional personal goal direction even if it excludes the interests of partners. Both mania and ADHD advertise themselves with high activity and both corrode social reciprocity but for different reasons. It appears that there are *no* conditions under which ADHD can be viewed as an "adaptation" if ADHD is defined in reference to intact executive functions. Mania may have enhanced fitness characteristics in some niches but can be a substantial impairment in mutualistic ones that are characterized by formal cooperation and extensive social rules.

Dysthymia combines traits of ADHD and mania. Excessive grandiosity in combination with impaired executive functions leads to chronic inconsistency between goals and outcomes. Ineffective problem solving is associated with an over reliance on demanding help from others and an expectation that the recipient is entitled to everything that they can get and

to much that they cannot. A "will to power" occurs in many dysthymics; their complaints have a tremendous potential not for self lowering but as a tool for manipulating other people and maintaining a relatively stronger position in hierarchies.

Thus, some of the treatment puzzles about mania, ADHD, ODD, and dysthymia are amenable to a sociobiological approach that includes ideas from complexity and evolutionary theories. Examples and treatment options are sketched for all four disorders.

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2. Kauffman S: *At Home in the Universe*. NY: Oxford, 1995

Paper #17. **On formulations that mania resembles leadership: A critique and model**

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**Abstract:** Bipolar disorder, the condition largely responsible for generating episodes of mania, appears to have been well-preserved in the human genome. Prominent characteristics of manic episodes, including energy, motivation, dominating or aggressive behavior, and optimism, have been formulated as alpha characteristics that would be favorable in selection. Yet, equally prominent features of manic episodes, including mixed or psychotic states, lack of contextual



relevance, and their presence as part of a potentially destructive recurrent illness that includes depression and is often associated with occupational decline, would appear unfavorable and not conducive to alpha status or to preservation in the genome. Characteristics of bipolar disorder or of mania that were salient over evolutionarily meaningful periods of time may no longer be relevant. Conversely, characteristics that seem prominent now may have been irrelevant over most of the time of selection. Aspects of bipolar illness other than mania could have resulted in its preservation in the human genome, with the susceptibility to have manic episodes as an epiphenomenon. We will draw on family, epidemiological, illness course, biological, and psychopathological studies to discuss these factors critically and to derive an evolutionary model of manic episodes in the context of bipolar disorder.

## Session 7. Attention and Pathology

### Paper #18. The Triune Brain In Relation To The Functional Analysis Of Attention

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**Abstract:** Modern concepts of attention have moved from the earlier notions of attention as a single monolithic function to that of a group of behaviors, each defined separately, with a specific articulated function for the organism; moreover, some theorists have posited that each specific function is dependent upon the integrity of a distinct brain region, although in the intact brain, the regions form an integrated system.

We have proposed a heuristic model of the factors involved in human attention, derived in large part from neuropsychological considerations of patients with seizures or other neuropsychiatric disorders. MacLean's concept of the Triune Brain has provided us with a remarkable armature upon which to build a concept of the organization and development of

attentional functions within the human brain, and to explicate how this organization for attention came to develop from an evolutionary point of view. We will describe our model and show its relation to MacLean's concepts of reptilian, neomammalian and mammalian brains.

### Paper #19. Upshifting and Downshifting the Triune Brain: Roles in Individual and Social Pathology

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All evolutionary approaches to human behavior share the fundamental premise that modern human beings have a long phylogenetic heritage going back billions of years to the primeval soup of life. But how does that ancient legacy integrate itself into the everyday behavior of the people of today? Building on Paul MacLean's three levels of the brain (neocortical, paleomammalian, and reptilian), phylogenetic progression-regression theory postulates that human experience, at any given moment, is the product of the dynamic interplay of newer progressive tendencies with older and often more urgent regressive ones. At any given moment, an individual's experience may be primarily progressive (*viz.*, primarily neocortical, rational, and abstract; culturally defined and targeted toward cultural goals), primarily regressive (*viz.*, primarily limbic and/or reptilian; motivationally compelling, feeling oriented, and imagistic; biologically rather than culturally targeted), or, more typically, some combination of the two processes. The theory postulates that regression is inherently pleasurable, easily effected, and reflects a loss or diminution of cultural coordinations, whereas progression in modern technological societies requires often intense and inherently nonpleasurable and/or unpleasurable processes of socialization and cultural programming requiring high levels of self-control, delay of gratification, and years of formal education. Indeed, the process of enculturation is one of discouraging, punishing, and erecting moral obstacles to the compelling phenomenon of phylogenetic regression.

Paul MacLean's model of the triune brain is an excellent vehicle for deconstructing regressive and progressive phenomena. Most generally, one may speak of progressing up or regressing down the triune brain hierarchy, but more subtle interactions by level are deducible as well. For example, specific malfunctions may be pretty much limited to the reptilian level (e. g., Parkinson's disease), the paleomammalian level (e. g., sexual or aggressive anomalies due to damage in septal or amygdaloid nuclei), or the neomammalian level (e. g., loss of memory or language capability), but more general psychopathology may involve conflicts between two levels (e. g., the neocortical/limbic conflict in neurosis) or all three levels in the "whole brain" pathology of childhood autism or schizophrenia. In this chapter, I will apply the logic of the triune-brain based phylogenetic progression-regression model to gender differences, individual psychopathology, and social forms of pathology such as the recent tragedy in Littleton, Colorado. Whatever the multiplicity of causes that set the stage and primed Eric Harris and Dylan Klebold to kill, or whatever proximal causes were in effect as they fired at their classmates, the regressive/progressive dynamics of the triune brain were the major players in the drama.

**Paper #20. On the Limits of an Evolutionary Conception of Psychopathology.**

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**Abstract:** Psychopathology is a concept about behavior problems in human beings and hence is culturally rooted. While all cultures have analogous concepts, Anglo European societies of the eighteenth and especially nineteenth century evolved its modern meaning. Evolutionary psychologists and psychiatrists have emphasized mechanisms and processes about behavior disturbances that essentially endow psychopathology with a phylogenetic history. If members of all human populations not only show genetic traits for psychopathology but also embody adaptive mecha-

nisms that make psychopathology understandable, the assumption of its universality, it just be the case that earlier hominid groups showed varieties of them. In short, varieties of psychiatric disorders during earlier phases of evolution must be regarded as real eventualities. Yet, researchers concentrating on evolutionary aspects of psychiatric disorders, although their formulations imply claims about "humanoid" varieties, do not examine these kinds of considerations. Hence, they offer a limited view of the evolutionary basis or origins of psychopathology. A host of theoretical dilemmas are reasons for this reluctance to discuss psychopathology during earlier phases of human evolution. These questions will be analyzed. Examples of an evolutionary conception of psychopathology will be presented. Some of the limitations of holding such a conception will be examined also.

**Session #8. Communication and Implications**

**Paper#21. Audiovocal Communication and the Triune Brain**

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**Abstract:** All social animals communicate, and this includes most mammals. Audiovocal communication—employing the vocal apparatus to transmit messages and the auditory nervous system to decode and interpret them—has an ancient evolutionary history, and the mechanisms mediating this form of communication have made possible an incredible diversity of signal forms, many of which are species-specific. Despite the fact that mammals share the same basic laryngeal 'hardware' for producing sounds, vocalizations vary tremendously in a number of dimensions, including length, loudness, pitch, tonality, and detailed internal structure.

These diverse communication sounds are controlled in the CNS by a limited set of neural structures. The 'triune brain' concept of MacLean provides a frame-

work within which most mammalian sound-producing neural circuits can be identified, and, in fact, it can be argued that a powerful force in the evolution of the 'triune brain' was the increased importance of vocal communication for most of the requirements of survival in a social species, including protection from predators, seeking out conspecifics for mating and social comfort, establishing and maintaining social bonds, and the use of cognitive skills for problem-solving in survival situations.

Apart from the lower brainstem, within which resides the motor neurons to the larynx and the respiratory system that form the 'final common pathway' for vocal expression, the major components of the triune brain—the 'reptilian' brain or R-complex, the 'paleomammalian brain' or limbic system, and the 'neomammalian brain' or neocortex, all play important roles in vocal communication. These three subdivisions each play different roles, for the most part, and their relative importance varies with the species under consideration, but even in humans, all three are essential for normal vocal communication.

The R-complex, shown by MacLean to underlie the performance of routines, can be shown to be important in the motor patterning of certain vocalizations. The limbic system, shown by MacLean to provide essential circuitry for the expression of the emotions, can be shown to be important in linking together vocal patterns and the motivation—perhaps also the context specificity—to produce the appropriate sound under the appropriate conditions. The neocortex—generally regarded in the context of vocal communication only for its essential role in speech and language—also plays a more general role in vocal communication that extends beyond humans to other mammals.

The anterior cingulate gyrus (ACG)—a form of transitional cortex that does not quite meet the usual cytoarchitectural criteria for neocortex—occupies an important role as the main cortical portal to the limbic system, and an important bridge between the neocortex and limbic structures. The ACG has connections both to downstream circuits directly related to vocal expression, and to auditory cortex in the temporal lobe. The latter plays an essential role in

differentiating the fine structural details of vocalizations—details that are essential in such diverse situations as prey seeking in echo-locating bats and recognizing the 'vocal signature' of friendly group members. The link between the ACG and temporal lobe auditory cortex may be important in regulating the differential processing of self-produced sounds and sounds produced by others. The ACG has been shown to be essential for the normal production of a basic mammalian vocalization—the 'isolation call' or 'separation cry'—a vocalization that is essential for the survival of dependent infants when separated from their caregiver. This same brain region has recently been shown to be activated in women when they are exposed to recordings of human infant cries (the human version of the mammalian separation cry). Thus, the ACG represents a key component of the triune brain—but one that resists being pigeon-holed as to whether it is part of the 'paleomammalian' or 'neomammalian' subdivision. Perhaps it is this neural structure that will provide the impetus to proceed with further study of the triune brain into the next millennium.

## Paper 22. **Communicational, Brain and Molecular Basic Plans**

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Abstract: Natural selection via the Darwin machine operates on the whole organism functioning in its world. Present living forms had ancestors who successfully competed and reproduced, in part because they extensively communicated and otherwise behaved in concert as well as competitively with others of their own kind (conspecifics). Psychiatric disorders represent disturbances in conspecific communication. The physiology of social communication would be an optimal basic science for psychiatry. This implies investigations of various organism levels (group, individual, organ, molecule) with special emphasis on their integration and suggests

that DNA and translated proteins highly important for communication represent ancient mechanisms important in human relations though at times misapplied so that the resulting behaviors are maladaptive (hence, "psychiatric"). Can mechanisms defined on the communicative behavioral level be considered as basic plans? MacLean's work fundamentally concerned such ancient structures and derived functions with important stages from reptilian and early mammalian stages of human evolution persisting still.

In 1830 St. Hilaire argued in public debate that invertebrates and vertebrates shared body plan features that could be defined as homologous (shared by a common ancestor). In opposition, Cuvier carried the day against the younger theoretician (too little evidence). But now Gehring<sup>2</sup> and others studying the homeobox gene complex vindicate St. Hilaire and provide evidence that not only do his lobsters show homology with vertebrates, but that many other animals do as well, including nematodes and fruitflies; parallel — though often highly modified—genes carry out functions in extraordinarily diverse organisms. Mating, social rank hierarchical adjustments, parenting, group foraging and group protection in vertebrates have depended in a major part upon conspecific communications. MacLean and Greenberg's pioneering work on social rank hierarchy in lizards showed that such perceptions and behaviors depended on striatal neural structures.

Far from the communicational level of observation, the nuts and bolts of natural selection depend on the DNA-RNA-protein machinery of the body present in every cell. Genes translate proteins that then function in the body apparatus and construct new versions of the organism in new generations. How *behavior* and *behavioral contingencies* of the whole organism are transmuted via particular genes and gene combinations remains mysterious although Benzer and colleagues in *Drosophila* have linked specific genes with particular behavior disruptions, e.g., rhythms, mating and memory. The first is conserved in vertebrates but the others not clearly so from current evidence so whether these constitute basic plan constituents is yet to be determined clearly. There is hope for optimism, however, if the utility of core

programs has been such that they never discontinued but only modified. Such core activities are mating, nurturance and social rank hierarchical adjustments. Only with lapses does convergent evolution occur.

The chromosome deletion syndromes of Angelman and Prader-Willi constitute experiments of nature because absence of particular genes results in altered communication. Angelman patients never learn to talk and laugh frequently. Prader-Willi patients when frustrated often behave with other people in a tempestuous demanding manner roughly parallel to children of approximately 3 years of age. The two syndromes exhibit deletions of approximately the same sizes and locations on chromosome 15. These are parentally imprinted genes so that the missing chromosome segment always stems from the mother in Angelman syndrome and from the father in Prader-Willi. This in turn relates to evidence that cortex normally stems from mother and hypothalamus from the father. Fragile X syndrome is another natural experiment; *form fruste* variations without other stigmata of the syndrome exhibit social anxiety. Also Williams syndrome patients with deficient posterior cortex but well developed frontal cortices are highly social people.

Thus research ranging from the behavior of fruitflies to patients handicapped with genetic deletions allows increasing dissection of inherited components of behavior, both basic and less basic. Brain imaging comparisons across species will furnish added information. We will watch with interest on which the features of the anole display use the same genes, neurons and stimuli as do parallel human displays? How are these modified in the two genomes and resultant brains? The details of how Paul D. MacLean's research program will be carried forward will form interesting new chapters.

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Paper #23. **The Adventures of MacLean & Pribram**

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**Abstract:** At mid-century, Paul MacLean and I did a series of experiments together. He was a delightful companion and it was a joyous experience all around. We continued the chemical stimulations studies begun by Warren McCulloch, Gerhardt von Bonin and Percival Bailey — concentrating on the medial and basal cortex which they had not been able to reach. We worked with monkeys, with acallosal opossums (they really smelled awful), and found the cortical region (orbitofrontal and perirhinal) excited by electrical stimulation of the vagus nerve. But then, when it came to writing up our results we encountered great difficulty. Paul's gift for naming, though often useful in promoting ideas, seemed to me to be applied rather rashly: The term "limbic" though used by Broca (his Grande Lobe Limbique) was more often restricted to the cortex of the cingulate gyms in cytoarchitectonics. My friend and mentor Jerzy Rose was dead set against extending the term to the entire mediobasal rim of the hemisphere. MacLean's persuasion won the day and I happily supported his enterprise since I had shown a commonality of physiological effects from electrical stimulation and a commonality of effects on behavior from resections of the variety of anatomical structures that comprised the Grande Lobe. More on this and the subsequent adventures of MacLean and Pribram.



**Planned Paper that could not be delivered**

**Why the "Enlightenment"? Neuroscience, the Triune Brain, and the Origin of Modernity**

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**Abstract:** The modern era began with an eighteenth century intellectual movement that called itself "the Enlightenment." Why was the transition to secular society, economic development and political freedom based on the image of bringing light to darkness? When I first met Paul MacLean in 1981, we discussed a hypothesis based on his conceptualization of the triune brain as it related to the development of artificial illumination and resulting changes in diurnal rhythms, mood, and confident social interaction with unknown strangers. This hypothesis can serve as a model of the far-reaching implications of MacLean's pathbreaking approach to human neuroanatomy. The combination of a functional approach to brain structure with analysis of both phylogeny (biological evolution) and social behavior (current adaptive consequences), in which MacLean was a pioneer, will doubtless take on ever-increasing importance as the integration of behavior genetics and neuroscience continues to revolutionize our understanding of human nature.



Price

## The schizotype as a dispersal phenotype: support from the theory of "variability selection".

In our book *Evolutionary Psychiatry*,<sup>1</sup> Anthony Stevens and I put forward the hypothesis that the genetic tendency to schizophrenia and schizotypy (called schizotaxia by Paul Meehl) had evolved because it also predisposed to the mental reorganisation ("mazeway resynthesis") which occurs in prophets and cult leaders, and gives them the unshakeable conviction in a new dogma which enables them to develop charisma and lead a group of colonists into a "promised land." When the mazeway resynthesis doesn't happen, for any reason, the individuals are recognised as schizotypes; when it happens and goes wrong, they are recognised as schizophrenics, with lowered fertility, but these lost genes are balanced by the increased reproduction of cult leaders, both within the cult due to increased reproductive opportunity (as, for example with David Koresh, whom God instructed to impregnate personally all the women in his cult), and of the cult as a whole when it expands into an adaptive radiation in the new habitat.<sup>23</sup>

This idea was received with incredulity by our friends, colleagues and reviewers. Now a new theory from Richard Potts, the director of the Smithsonian Institute's Human Origins Program, has provided what I think is some support for our own hypothesis.<sup>4, 5</sup> I will discuss this new theory of "variability selection", but first I will give a brief summary of our latest thinking, in the form of an abstract for the ASCAP meeting in Hamburg.

### The schizotype as a *dispersal phenotype*

One can discern in schizophrenia and the schizotypal personality a "dispersal phenotype"; that is, an evolved strategy which in the past has served to *disperse the* organism around the full range of its *potential* habitat; it is an alternative to the "*maintenance phenotype*" which is optimally adapted to the existing *habitat*.<sup>6</sup> In

the schizophrenic *process*, we can discern a *vector* influencing the individual to leave the natal group (into which he or she has been born and *indoctrinated*) and to *disperse* into *uncharted* terrain. Both attractive and repulsive forces *promote this vector*. On the one hand, the patient is drawn to some *destination* which is often conceptualised as a "*promised land*", and goes there under the influence of messianic *delusion*, hopefully with a following of *disciples* to take care of the more *practical aspects of life* and performing much the same function as psychiatric *nurses*. On the other hand, the patient is *driven from the natal area* by paranoid delusions of *persecution*, often accompanied by hostile voices. The *end result* is a new community, with a new world view, *incompatible with the natal group*. Unfortunately, the process often goes astray, and the patients *end up*, not in a promised land, but in a shop doorway or a psychiatric ward. Or there may be a more benign outcome, and they may remain in the *natal group* as shamans, mystics and holy men.

### Variability selection

Richard Potts has drawn attention to the extreme climatic variability of the last six million years on earth, and especially the last 700,000 years. There have been many cycles in which climate has varied from extreme heat to extreme cold, culminating in the ice ages and their tropical intervals. The oscillations have been much greater than those of the preceding 60 million years. Many species and races of hominids and other animals probably went extinct, either in the cold phases or in the hot phases; for instance, it is thought that the cold-adapted Neanderthals went extinct during one of the warm periods. Potts argues that this winnowing of genes has been an important factor in human evolution, and has led to the evolution of climatic adaptability, so that selection has not been for fitness in a particular habitat, but for the capacity to change one's physiology and behaviour to suit a

variety of extreme habitats. These ideas have been taken up and expanded by Michael Davies and his colleagues in their book, *Humankind the Gatherer/Hunter*<sup>7</sup> and more recently in this newsletter.

Now, I think it is difficult to imagine selection for the versatility needed to survive extreme temporal variation in climate. I cannot do the mathematics, but I would think that there would not be sufficient time for races and species to develop the necessary characteristics, on a trial and error basis, to deal with oscillations of several thousand years, even if facilitated by prior adaptation to shorter temporal cycles. Unless, that is, there was a pre-adaptation to spatial variation in the form of simultaneous adaptation to a variety of geographical extremes of habitat. If, at one and the same time, man is adapted both to the freezing conditions of Lapland, and to the tropical heat of the African rainforest, it would not matter if the climate see-sawed over time from one extreme to the other. In the super-hot times, the Africans would be burnt or dehydrated to extinction, and the Laplanders would die of heat, but there would be a proportion of Laplanders who were adapted to the African rainforest and would survive a tropical Lapland. Likewise, when the Laplanders froze solid, and the Africans died of unaccustomed cold, there would be a small proportion of Africans who were adapted to the Lapland climate, and would survive an arctic form of Africa. We might expect a recursive interaction between temporal and spatial versatility: Potts points out that selection for temporal versatility "may encourage the spread into diverse habitats" and the capacity for this spatial versatility would, in return, facilitate the evolution of temporal versatility.<sup>5</sup>

This scenario of the EEA requires a far greater migration of humanity than is currently envisaged. Not only must there be a continuous movement of people out of Africa into Europe and Asia, there must also be a return movement of people back into Africa, so that the southern part of Europe would be a sort of dual carriageway providing passage back and forth (see figure 1). We don't know how the trip was made. Perhaps there was a move of about a hundred miles in each generation, with a sub-group splitting off and

going just that bit further, leaving the rump on the route; in which case the return journey might take some thousands of years. But this would be quick enough to provide the gene mix at both ends of the dual carriageway.

If this happened, the importance of group splitting is greatly enhanced. In order to provide the gene mix, each of the migrating populations would have to split at least every generation. There may have been many ways that the groups split. In order to clarify thinking about this matter, we can offer a classification of splitting into homopistic fission and heteropistic fission. The word homopistic is derived from the greek for "same" and "belief" whereas heteropistic means "other belief". Many types of splitting occur when a group gets too big. The split may be amicable, and then two peaceful tribes live side by side, sharing the same customs and beliefs; or it may be antagonistic, due to some quarrel between families, and then one gets the kind of splitting described by Chagnon in the Yanomamo; but even in the antagonistic case, the two sub-groups are likely to share customs and beliefs - there has been homopistic fission.

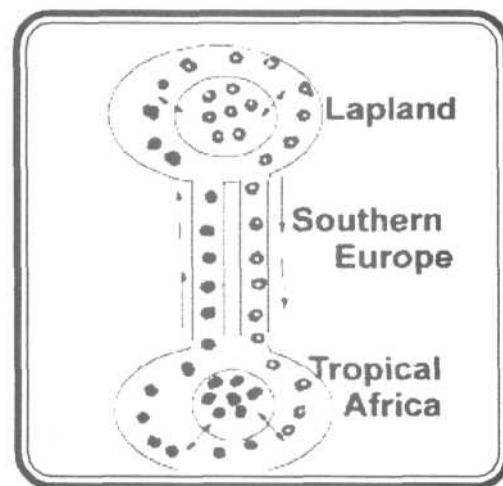


Figure 1. Schematic representation of bidirectional migration of early hominid groups from tropics to arctic and back again, the round trip taking between one and ten thousand years.

In contrast to this homopistic fission, we have the accelerated, forced splitting when a cult develops a new vision of reality, and develops paranoid ideas about the existing group and also messianic ideas

about moving to a promised land. This is heteropistic fission. The group is on a vector, fuelled by new ideas - ideas which seem revelatory to the members of the new group, and delusional to members of the old group - ideas which repel the new cult from its parent group, and at the same time attract it to a destination at some remove from the parent group.

There may well be an underlying migration myth, setting the promised land at some point of the compass. For instance, the Aryan myth about "lebensraum" to the east, and the American myth of "Go West, young man"; or the precolonial Brazilian myth of the "land without evil" beyond the mountains. In each generation a prophet might arise to personify this myth, and to take a sub-group with him one further stage in the long progression from Lapland to Africa, and back again.

### **Bird and fish migration**

It is interesting to consider bird and fish migration in this context.<sup>8-12</sup> It appears that in some species all the population migrates, and this may be because they are not adapted to both the winter and the summer habitat. In this case, migration would make them sensitive to climatic change, and they would not survive the sort of fluctuations Potts is talking about. But some species are partial migrators, such as the robin. In these species, after an autumnal battle for territories, the territory holders stay put, and those who do not win territories migrate. The species is therefore adapted to survive both northern and southern climates during winter. Possibly some individuals do not migrate back in the spring, but stay and breed in the south - I do not think there is sufficient evidence either to establish or refute this idea. If that were the case, there would be a few individuals in the robin population who would survive either an ice-age or a severe thaw.

And maybe if they looked closely, ornithologists might find a few one-off "crazy" individuals who failed to migrate even in those species who are thought to be total migrators. (I am thinking, of course, of the swallow in Oscar Wilde's story of "The Happy Prince" - the swallow did not really stay in order to care for the

prince, he was a genetic stayer, and the myth of looking after the prince was a rationalisation to explain his bizarre conduct.)

In both migrating and failing to migrate, the robin would be doing every year what we suggest the human ancestor was doing every thousand years. Perhaps this is the reason why migration is so common in birds and fish. The non-migrating species were killed off by the sort of fluctuations described by Potts. This does not, of course, explain why birds migrate, because migration was a pre-adaptation, and evolved for reasons other than coping with temporal climatic variability. But when the climate started to oscillate so wildly, it explains why there was differential survival of the birds and fish which had already evolved the system of bidirectional partial migration.

### **The importance of religion**

Religion is a universal feature of the societies of mankind.<sup>13</sup> Some have thought that its ubiquity is due to the fact that it binds a group together, legitimates leadership and hierarchy, and deflects onto the godhead the aggression which would otherwise be directed at the group leader when things go wrong.

But it also has a great capacity for fostering group splitting. This we can see from the history of almost any sect. In many cases the difference of dogma or ritual may be slight, and be dependent on clashes between powerful personalities in the sect. This might be called the gradual or conservative form of heteropistic fission. But there is also the radical form of cult formation, and it is of course this form that we think is important for the evolution of schizophrenia.

Religions are remarkable because their array of arbitrary beliefs about the gods, the world, the origin of man and so forth, gives a wide choice of incompatible belief options which may be used to separate groups, without changing their beliefs about important things like foodstuffs, medicines, animals and cultural knowledge which are necessary for survival. So that an entire belief system can be radically altered without altering the group's capacity to control the environment.

## Conclusion

We originally put forward our group splitting hypothesis thinking it might have an important role in group selection. Then it was pointed out to us (correctly) by anti-group-selectionist referees that it might be advantageous to an individual to leave the group with a band of devoted followers, and our hypothesis could be justified on the grounds of individual selection, without invoking the controversial subject of group selection. Now there is an additional evolutionary reason for the survival of group fissioning mechanisms. Groups which did not divide quickly enough to maintain adaptation to both Lapland and Africa were killed off in one or other of the climatic extremes described by Potts, just like those species of birds and fish that did not evolve bidirectional partial migration.

More attention needs to be paid to both human migration and human group splitting, both by experimental social psychologists and by social anthropologists. We do not know of a single monograph devoted to the fissioning of human groups; please let us know if we are ill-informed.

## Summary

Potts suggested that the human capacity for versatility evolved as an adaptation to cope with temporal variation in climate over the past six million years. Here it is suggested that a pre-adaptation of versatility in relation to spatial variation in climate would have facilitated the evolution of versatility in relation to temporal variation. This requires the hominid gene pool to be simultaneously adapted to both arctic and tropical climates. This could have been achieved by bidirectional migrations from arctic to tropics and back again, taking something in the order of one thousand to ten thousand years. Such migrations would be accelerated by frequent group splitting. It is suggested that in addition to homopistic splitting in which the daughter groups share the same beliefs, there has been an important contribution from heteropistic splitting, in which a daughter group breaks away from the parent group because of a new and different ideology. The schizotypal personality allows the "mazeway resynthesis" of the cult leader, which gives

him the charisma to attract a group of people around him, indoctrinate them into his new ideology, and lead them off into a promised land. The increased reproduction of cult leaders balances the loss of genes from those schizotypes who develop schizophrenia.

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## Discussion of Migration Hypothesis

### To Val Geist from John Price

Thank you most warmly for replying to my enquiry about dispersal and maintenance phenotypes. I will certainly get your book *Deer of the World*. I am appending a very speculative article due to appear in the *The Across Species Comparisons and Psychopathology (ASCAP) Newsletter* shortly. We are trying to bring certain forms of psychopathology more into the realm of biological discourse, but it is difficult as, for instance, delusions leave less of a mark in the fossil record than antlers; moreover, biologists are reluctant to take an interest in our material, probably because they consider it too "soft". Anyway, I have enjoyed the broad sweep of your biological thinking, and if you have any comments on what follows, they would be welcome.

### To John Price from Val Geist

Thank you for your most interesting reply. If you are at the beginning of my *Life Strategies...* book, then -given your interest - the last third will be of some interest to you. I recognised some three decades ago that hominids followed the same pattern of dispersal-speciation as found in many lineages of ungulates and carnivores. However only one primate lineage showed this pattern - ourselves. The engine of dispersal speciation I identified in my 1978 book as the glacial -interglacial pulses. However, while all major speciation steps are associated with glaciations, not all glaciations are associated with hominid speciation. Significant speciation events occurred during the Penultimate Glaciation (Riss) beginning about 225,000 years ago. This was a very massive glaciation, far beyond the subsequent Wurm/Wisconsin glaciation and led to the extinction of our parent species *H. erectus* and the subsequent appearance of *H. sapiens*. Our parent species appears about 1.9 my ago with the

onset of the Major Glaciations, the Pleistocene proper. It appears to change relatively little till extinction about 1.7 my later- a very good survival record indeed. The earlier australopithecine/*Homo* transition lies back about 2.5 my, at the beginning of the Minor Glaciations. In every case hominids co-speciate with ungulates. Once the breakthrough into the dry steppe had taken place, hominids were free to disperse and adapt to the temperate zones, the domain of our parent species; deserts and periglacial habitats were the domain of our species. That is, the Riss Glaciation expanded our capacities so that extremes in dry or cold climate were no longer barrier to our dispersal.

Our adaptability is in part a consequence of adapting to extreme seasonality. That is, we can exist in situ under winter and the subsequent (tropical) summer conditions. There exists no need to postulate massive movements of humans with glacial cycles, although some such movements must have taken place. Our parent species is an interglacial resident of Europe, for instance. During the Upper Palaeolithic (in periglacial environments), which is very late indeed in our history, the circumstantial evidence suggests very widespread geographic movement as absolutely routine.

There are some potential tests of your interesting hypothesis about the evolutionary origin of Schizophrenia. If it is dispersal related does one find that persons with schizoid tendencies grew up under environmentally superior conditions? Are they are, on average, taller and better developed physically, and have slightly larger brains? Are they comparatively "fearless"? Are they better at strategy than tactics? Mentally, are they surprisingly good dealing with contingencies? What abilities do schizoid persons bring to the colonization process of strange, unknown landscapes so as to be a magnet for others to follow?

### To Val Geist from John Price:

Thank you for your helpful comments -I am still reading your book, and will now turn to the section on glaciations. I take your point about adaptation to seasonal variation in climate as being an alternative pre-adaptation (alternative to long-term bidirectional migration) to facilitate the evolution of versatility in dealing with long-term temporal variation in climate. Perhaps we might put this to the Davies and to Rick Potts. In the meantime, we would very much like to print your comments after my article in *The ASCAP Newsletter*- may we have your permission?

### To John Price from Val Geist

Yes, please feel free to publish my commentary after your article. I am all for discussions and the airing of viewpoints. As to bidirectional north south migrations in phase with glacials and interglacials: Europe north of the Alps (and other East-West mountain ranges) is a "mouse trap" for early humans. As warm interglacials turn to glacials big pockets of warm-temperate climate remain north of the Alps, but shrink as cooling proceeds. Those caught in the pockets are surrounded by inhospitable climates. They die out as the pockets or moderate climates are snuffed out. Conversely, with an interglacial advance, pockets of warm climate emerge north of the Alps. By the time these pockets fuse with those south of the Alps they form a superb arena for rapid colonization by southern



forms. Rapid colonization is a powerful speciation force, as you will read in my book. Also please note: modern humans feature characteristics of northern Ice Age mammals - not of southern African ones! As we invaded periglacial regions colonizing north, we evolved

exactly as did other large mammals, woolly rhinos & mammoth, cave bear and Irish elk, etc. However, we broke with that in the Upper Paleolithic, and did "unbiological things" from then onward.

### To John Price from Michael Davies

Many thanks for your draft article "The schizotype as a dispersal phenotype."

In *Humanity's Descent*, Potts is describing homind (and human) evolution in Africa. The climatic oscillations in Africa consisted of switching between warmer, wetter and cooler, dryer conditions. The cycle could be as short as a few hundred years, and the transition could be rapid.

The genetic evidence is that this warmer/wetter and cooler/dryer oscillation had dramatic selective effects. The ancestral human population crashed at least once in the last 300,000(?) years from some 100,000 individuals to around 10,000.

Humankind, even the Eskimo, retains the characteristics of a tropical species. The growing consensus is that humankind radiated out of Africa in the last 100,000 or so years. We are not aware of any evidence to support a tropical/artic migration and any consequent adaptation.



Consequently your argument could be that the schizotype was adaptive during this phase.

On a minor note, our book (1992) predates Potts (1996). We did not take up and expand on Potts' work. Rather our theory predicted the existence of what Potts eventually discovered, that human evolution by natural selection had been influenced decisively by climate variability. By 1992, we had demonstrated to our satisfaction that human social change has been affected by a gatherer-hunter capacity to cope with climatic variability.

# ABSTRACTS & EXTRACTS ...

**Salzen E: Emotion and self-awareness. *Applied Animal Behaviour Science* 1998;57:299-313.**

**Abstract:** An ethological analysis of emotional behaviour suggests that it consists of somatic and autonomic elements of behaviours that are thwarted or in conflict (unpleasant emotions). Such displays change the behaviour of social partners which may end the thwarting, whereupon there is a relaxation and switch to the intended consummatory behaviour (pleasant emotions). Self-perception through distance exteroceptors allows the individual to respond to its own emotional displays as if they were those of a social partner. This is the basis of the experience of emotions and of self-awareness and self-control. Vocal signals give the most veridical self-perceptions and are produced and shaped by emotional actions. Speech and words may have developed as vocal signals associated with and symbolizing social actions with particular objects. These symbols are self-produced and so that sequential symbol use, i.e., thinking, becomes possible. Self-perception begins in infancy with visuo-kinesthetic discriminations of bodily actions giving the 'sensori-motorself. Internal motivational states add hedonic value, i.e., give feelings and a 'feeling self. Self-perception of one's own emotional displays forms the 'emotional self. Finally, the self-produced signals of 'me' and 'you' establish the 'cognitive self, and the 'I' the self-concept. Neural feedback processes, from the level of recurrent collaterals of single neurones to that of cortico-cortical fibres of the neocortex, are not in themselves sufficient for self-awareness. Feedback from the actions of the individual to the neocortical sensory and perceptual systems is required if a discriminated self is to be represented in the association areas. These representations interact with a language systems which associates 'me' with self-representation T with the cortical and subcortical processes of perception, action and motivation to give full awareness of the self. Self-awareness in domesticated animals, as in other vertebrates, depends on the degree of external self-perception possible, on social organisation, on social

communication through emotional signalling, and on acquisition of a symbolic language system. The phylogeny of self-awareness is briefly considered in terms of levels of awareness, from sensori-motor to cognitive self-awareness, and the evolution of symbolic vocal communication enabling a concept of self and a knowledge of this concept (i.e., cognitive self-awareness). The development of self-awareness in the human infant is similarly considered. Self-perception of emotion may be the basis of enjoyment and suffering but language may be necessary for a knowledge of these feelings and for continued suffering in the absence of the evoking stimulus or associated stimuli. The implications of this analysis for the welfare of domesticated animals are indicated.

**Freeman WJ: Chaotic state transitions in brains as a basis for the formation of social groups. In Albert A (Ed): *Chaos and Society*, Washington D.C.: IOS Press, 1995, pp 355-369.**

**Abstract:** Experimental observations on the brain activity that ensues on sensory stimulation of animals show that sensory cortex engages in the construction of activity patterns in response to stimuli. The operation is not that of filter or correlation mechanism. It is a state transition by which the cortex switches abruptly from one basin of attraction to another, thereby to jump from one spatial pattern to another as do frames in a cinema film. Each transition involves learning, so that cumulatively a trajectory is formed by each brain over its lifetime. Each spatial pattern as it occurs reflects the entire content of the trajectory. Subjectively, the several patterns of the sensory cortices combined in the limbic system constitute the biological basis of consciousness, for which the role is to make available to the subject the entire body of experience as the basis for each new step, word or decision. This constitutes also a new meaning for the concept of intentionality. It follows that each brain creates its own trajectory and its own frames of reference which are not accessible by any other brain. How, then, can two or more brains be shaped by learning so as to form cooperative pairs for reproduction and groups for survival? Evolution has provided a biological mechanism that first



came under scientific scrutiny in the form of Palovian "brain washing." Under now well-known conditions of stress in the internal and external environments of the brain, a global discharge takes place, following which the brains sustains a remarkable period of malleability and adaptiveness. Examples of the process include hazing by fraternities, indoctrination of recruits in military "boot camps," tribal dance ceremonies, evangelical religious conversions, and, most importantly, sexual orgasm as the basis for pair bonding and cooperation for the nurture of the young. An excessive concern for computational algorithms currently leads many scientists to neglect these noncomputational processes as the bases for pair bonding and group behavior. Nonlinear dynamics and the theory of chaos offer new approaches to understanding these neurobio-logical mechanisms by which societies are formed and maintained.

**Chadwick PK: *Schizophrenia: The Positive Perspective. In Search Of Dignity For Schizophrenic People.* London & New York: Routledge, 1997, pp. 146-7**

**Extract:** Writing, however, need not be for others. Via the keeping of a journal all manner of thoughts and experiences can be ventilated and problems genuinely worked through and solved. Journal writing testifies to the possibility of effective therapy without transference. A journal has many advantages. For example, it sets no time limit to your verbal delivery. It never gets exasperated or bored, nor does it ever criticize or rebuke you. It never forgets anything, its cost is minimal, it can travel with you and it demands nothing from you other than that you will fill it with meaningful useful writing so that in a way it is "allowed" to fulfil its function. It allows you to find your own interpretations, never chides you for lack of motivation or evasiveness and it never misunderstands you or gets romantically or sexually involved with you. It never probes or questions you if you are "late" and it is never shaken by outbursts of emotion - all that happens is that the pen is more indented into the page. It allows you to be yourself completely and it will receive what you say faithfully at any time of the day or night. The deficiency, of course, is that there are none of the chal-

lenges or positive consequences of a relationship - and none of the positive spin-offs of criticism or of the sense of development of a relationship.

**Silver LM: *Mouse Genetics: Concepts and Applications.* New York, NY: Oxford University Press, 1995, pp.11**

**Extract:** [M]ice and humans (as well as all other placental mammals) are even more similar genetically than they were thought to be previously. An astounding finding has been that nearly all human genes have counterparts in the mouse genome ... Thus, the cloning of a human gene usually leads directly to the cloning of a mouse homolog, which can be used for genetic, molecular, and biochemical studies that can then be extrapolated back to an understanding of the function of the human gene. In only a subset of cases are mammalian genes conserved within the genomes of *Drosophila* or *C. elegans*.... [T]hree types of information have been used to build phylogenetic trees for distantly related members of the animal kingdom -paleontological data based on radiodated fossil remains, sequence comparisons of highly conserved proteins, and direct comparisons of the most highly conserved genomic sequences, namely the ribosomal genes. The most parsimonious model is one in which flies (*Drosophila*) and nematodes (*C. elegans*) diverged apart from the line leading to mammals just prior to the time of the earliest fossil records in the pre-Cambrian period which occurred 570 million years ago. The divergence of mice and people occurred relatively recently at 60 million years before present.... [H]umans and mice are ten times more closely related to each other than either is to flies or nematodes. Although the haploid chromosome number associated with different mammalian species varies tremendously, the haploid content of mammalian DNA remains relatively constant at approximately 3 billion basepairs. ... [T]he underlying genomic organization has also remained the same as well. Large genomic segments ... have been conserved virtually intact between mice, humans, and other mammals.... [A] rough replica of the human genome could be built by simply breaking the mouse genome into 130-170 pieces and then pasting them back together again in a new order.

**Blood A, Zatorre RJ, Bermudez P, Evans AC: Emotional responses to pleasant and unpleasant music correlate with activity in paralimbic brain regions. *Nature Neuroscience* 1999;2:382-387.**

**Abstract:** Neural correlates of the often-powerful emotional response to music are poorly understood. Here we used positron emission tomography to examine cerebral blood flow (CBF) changes related to affective responses to music. Ten volunteers were scanned while listening to six versions of a novel music passage varying systematically in degree of dissonance. Reciprocal CBF covariations were observed in several distinct paralimbic and neocortical regions as a function of dissonance and of perceived pleasantness/unpleasantness. The findings suggest that music may recruit neural mechanisms similar to those previously associated with pleasant/unpleasant emotional states, but different from those underlying other components of music perception, and other emotions such as fear.

**Extract:** Listeners who have been exposed to the Western tonal idiom typically respond readily to dissonance, even in the absence of formal musical training.... [L]esion and functional imaging studies indicate that regions of auditory cortex within the right superior temporal gyrus are specifically involved in analysis of pitch and timbre, and that working memory for pitch entails interactions between temporal and frontal cortices. Few data are available concerning the affective component of music processing. A... case history of amusia, however, has suggested that perceptual and emotional analysis of music may be dissociated. In parallel with visual face processing, judgments of affective content of a melody (happy versus sad) can be made even in the complete absence of any ability to identify or recognize a melody....

rCBF changes in specific paralimbic and neocortical areas known to be involved in affective processing correlate with increasing dissonance or consonance. These include right parahippocampal gyrus, right precuneus, bilateral orbitofrontal, medial subcallosal cingulate and right prefrontal polar regions....

Many studies of emotion have examined fear perception and conditioning. The amygdala, particularly in the left hemisphere, has been clearly implicated as a key structure in fear processing. In the present study, amygdala activation was not detected, and activated structures were found primarily in the right hemisphere.

**Kim JJ, Krupa DJ, Thompson RF: Inhibitory cerebello-olivary projections and blocking effect in classical conditioning. *Science* 1998;279:570-573.**

**Abstract:** The behavioral phenomenon of blocking indicates that the informational relationship between the conditioned response and the unconditioned stimulus is essential in classical conditioning. The eyeblink conditioning paradigm is used to describe a neural mechanism that mediates blocking. Disrupting inhibition of the inferior olive, a structure that conveys unconditioned stimulus information (airpuff) to the cerebellum prevented blocking in rabbits. Recordings of cerebellar neuronal activity show that the inferior olive input to the cerebellum becomes suppressed as learning occurs. These results suggest that the inferior olive becomes functionally inhibited by the cerebellum during conditioning, and that this negative feedback process might be the neural mechanism mediating blocking.

**Baynes K, Eliassen JC, Lutsep HL, Gazzaniga MS: Modular organization of cognitive systems masked by interhemispheric integration. *Science* 1998;280:902-906**

**Abstract:** After resection of the corpus callosum, V.J. a left-handed woman with left-hemisphere dominance for spoken language, demonstrated a dissociation between spoken and written language. In the key experiment, words flashed to V. J.'s dominant left hemisphere were easily spoken out loud, but could not be written. However, when the words were flashed to her right hemisphere, she could not speak them out loud, but could write them with her left hand. This marked dissociation supports the view that spoken and written language output can be controlled by

independent hemispheres, even though before her hemispheric disconnection, they appeared as inseparable cognitive entities.

**Maguire EA, Burgess N, Donnett JG, Frackowiak RSJ, Frith CD, O'Keefe J: Knowing where and getting there: a human navigation network. *Science* 1998;280:921-924.**

Abstract: The neural basis of navigation by humans was investigated with functional neuroimaging of brain activity during navigation in a familiar, yet complex virtual reality town. Activation of the right hippocampus was strongly associated with knowing accurately where places were located and navigating accurately between them. Getting to those places quickly was strongly associated with activation of the right caudate nucleus. These two right-side brain structures function in the context of associated activity in right inferior parietal and bilateral medial parietal regions that support egocentric movement through the virtual town, and activity in other left-side regions (hippocampus, frontal cortex) probably involved in nonspatial aspects of navigation. These findings outline a network of brain areas that support navigation in humans and link the functions of these regions of to physiological observations in other mammals.

**Reisner IR, Erb HN, Houpt KA: Risk factors for behavior-related euthanasia among dominant-aggressive dogs: 110 cases (1989-1992). *J Am Vet Med Assoc* 1994;205:855-863.**

Abstract: Establishing a prognosis for dogs with dominance-related aggression is difficult. Some dominant-aggressive dogs respond well to treatment; others continue to be serious risks for their owners. A study was performed to identify characteristics of dominance-related aggression and to identify risk factors associated with whether aggressive behavior led to euthanasia. Medical records of 110 dogs with dominance-related aggression were examined retrospectively; characteristics of owner-directed aggression and eventual outcome of the dogs were recorded. By means of logistic regression to benign dominance

challenges and body weight >18.2 kg were associated with outcome. In the second model, unpredictability of aggression and a history of being purchased were associated with outcome. We concluded that dominance-related behavior can be subclassified according to severity and type and that outcome (ie, euthanasia) may be predictable in some cases.

**Koshimizu K, Ohigashi H, Huffman MA: Use of *Ver nonia amydalina* by wild chimpanzee: possible roles of its bitter and related constituents. *Physiology and Behavior* 1994;56:1209-1216.**

Abstract: Bitter principles and related constituents have been isolated from *Ver nonia amydalina* (Compositae), a plant ingested by wild chimpanzees sometimes suffering from parasite-related diseases in the Mahale Mountains National Park, Tanzania. These isolated constituents were the known sesquiterpene lactones (vemodalin, vernolide, hydroxyvemolide), and newstigmastone-type steroid glucosides...: for bitter tasting constituents and... nonbitter related constituents). Antiparasitic activity tests of these constituents together with quantitative analyses of the major active constituents, vemodalin and vemonoside B. supported the hypothesis that Mahale chimpanzees control parasite related diseases by ingesting the pith of this plant, found to contain several steroid-related constituents, while the major steroid-related constituents ... do not taste bitter themselves, it was hypothesized that the highly bitter constituents including vernadalin may play an important part as signals to the ingester guiding their choice of the appropriate plant part, and possibly also as signals which help to control the amount of intake.

Extract: At Mahale in 1987, co-author MAH observed an ill female chimpanzee meticulously remove the leaves and bark from several young aerial shoots of the tree *Vernonia amygdalina* after which she chewed the exposed pith and swallowed only the highly bitter tasting juice. Twenty-four hours after ingesting the juice..., her condition greatly improved and she resumed her normal activity. A similar incident was again observed by Huffman in 1991.

**Byrne R: TAie *Thinking Ape: Evolutionary Origins of Intelligence*. New York, NY: Oxford University Press, 1995, pp. 5**

**Extract:** Healthy argument is not bad thing, but if the subject is to be a scientific one there must be ways to resolve the disagreements — at least in principle. Much of the subject of palaeoanthropology is simply not science, although it uses many of the tools of science. Theorizing about hominid behaviour is a subject close to detective work; detective work, however, in which the results are never going to be dramatically confirmed. An Australopithecus is just never going to jump up and say, "OK, you got me nailed: I've got my hands up! I admit I had no consonantal phonemes, but I was a real nifty scavenger from sabretooths." Detective work is great fun, and in the hands of experts... it is the best that we can ever hope [to understand] the events of the past 5 million years of our evolution..

[Conclusions will always be speculative, fragile and liable to tumble at the sight of new evidence. This applies even where sophisticated modern techniques are used. The date of the origin spoken language has always excited speculation. Computer modeling of the vocal tract of a Neanderthal suggested that their larynx was a very different shape than that of modern humans: Neanderthals could not have produced the range of vowels that we can. However, the same technique applied to chimpanzees 'shows' that they cannot produce sounds that they do in fact produce.

... Claims about Neanderthal speech are bound to be fragile things. The recent finding of a hyoid bone... indicates a larynx much like ours in a human of 60 000 years ago, predating most Neanderthals. This date is also 20 000 years before the cave paintings of France and Spain, which are often argued to signal the beginning of symbolic ability in our ancestors — and thus, supposedly, date the origin of language.

**Knowlton BJ, Mangels JA, Squire LA: A neostriatal habit learning system in humans. *Science* 1996;273:1399-1402.**

**Abstract:** Amnesic patients and nondemented patients with Parkinson's disease were given a probabilistic classification task in which they learned which of two outcomes would occur on each trial, given the particular combination of cues that appeared. Amnesic patients exhibited normal learning of the task but had severely impaired declarative memory for the training episode. In contrast, patients with Parkinson's disease failed to learn the probabilistic classification task, despite having intact memory for the training episode. This double dissociation shows that the limbic-diencephalic regions damaged in amnesia and the neostriatum damaged in Parkinson's disease support separate and parallel learning systems. In humans, the neostriatum (caudate nucleus and putamen) is essential for the gradual, incremental learning of associations that is characteristic of habit learning. The neostriatum is important not just for motor behavior and motor learning but also for acquiring nonmotor dispositions and tendencies that depend on new associations.

**Dehaene S, Spelke E, Pinel P, Stanescu R, Tsivkin S: Sources of mathematical thinking: behavioral and brain-imaging evidence. *Science* 1999;284:970-974.**

**Abstract:** Does the human capacity for mathematical intuition depend on linguistic competence or on visuo-spatial representations? A series of behavioral and brain-imaging experiments provides evidence for both sources. Exact arithmetic is acquired by language-specific format, transfers poorly to a different language or to novel facts, and recruits networks involved in word-association processes. In contrast, approximate arithmetic shows language-independence, relies on a sense of numerical magnitudes and recruits bilateral areas of the parietal lobes involved in visuo-spatial processing. Mathematical intuition may emerge from the interplay of these brain systems.

# ASCAP

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