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WORKSHOP V

BRAIN AND MIND
evolutionary perspectives

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inherited (Krubitzer, Dennett, Rozin).

A second important concept is modularity, the idea that the brain and mind are composed of many units, each serving a particular function and employing mechanisms adapted to that function, rather than being a general-purpose machine for solving problems (Gallistel, Dennett). The modular organization is reflected in the development of conceptual abilities in infants (Carey) and the experiments that have revealed these abilities are an example of reverse engineering, taking apart the system to see how it works. The same approach, guided by evolutionary principles, is being used to analyse functions of the mind such as language, emotions and apparently irrational behaviour (Rozin, Pinker). The opposite approach, used by researchers into artificial life and some designers of robots, is to employ evolutionary principles to build a behaving 'organism' from scratch (Dennett).

As is clear from the discussions that follow, more questions have been raised than answered. More important, though, is the demonstration that viewing brain and mind through the lens of natural selection is revealing a rich seam of ideas. Ultimately these should help to integrate the disparate approaches of contemporary neuroscience and cognitive psychology.

Start with Darwin ....

John Tooby and Leda Cosmides*

Since its emergence in the Renaissance, the scientific project has transformed the way we see and understand the world, revealing the vast, strange cosmos of modern astronomy, physics and biology. Galileo and Newton united the celestial and terrestrial realms, previously considered distinct, into a single seamless

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mechanical world governed by physical causality; similarly, Darwin showed how living organisms owed their complex organization to physical causality. As a result, biological organization was demystified and drawn into the widening synthesis of scientific materialism.

Although this new understanding has been exhilarating for many, it has seemed threatening and dehumanizing to others. In particular, the expansion of the natural sciences to include the human mind, behaviour and culture has been bitterly resisted. Indeed, attempts to rationalize the placement of the human and the mental forever beyond the scope of the natural sciences have become more desperate as the scientific project has loomed ever closer to the analysis of the human species. This reaction has been so widespread and deeply felt that for more than a century after the publication of *On the Origin of Species* (Darwin, 1859), the behavioural, social, psychological and even the neural sciences all essentially remained outside a darwinian synthesis, despite many promising efforts.

Darwin correctly anticipated his most controversial claim to be the equal application of the evolutionary perspective to the mental as to the physical. At least since the time of Descartes, educated opinion had been quite willing to accept the body as a machine, subject to physical law. Mental phenomena, on the other hand, especially human abilities such as reasoning, goal-seeking, language, feeling and culture, continued to be separated off by religious belief or an intuitively plausible dualism into an extraphysical, extranatural sanctuary; here traditional concepts could survive undisturbed. Darwin worked to refute the dualistic claim that mental phenomena lay beyond an abyss that could not be bridged by evolutionary causality and explanations. He carefully showed that human mental faculties, whatever their material basis might be, showed unmistakable signs of evolutionary patterning and so must be explicable in the materialist evolutionary terms that account for the origin of species and the

acquisition of specific physical characteristics.

So Darwin's achievement went beyond the principled unification of the human and nonhuman living world within the framework of natural science. It opened a path to the principled unification of the mental and physical worlds, the incorporation of the mental characteristics of humans and other animals into the same system of material causation that explains leaf shape and the osprey's eye. This laid the groundwork for a transformation of the sciences of biology and psychology, which had been descriptive, particularist, fuelled by unguided observation, and concerned with cataloguing phenomena and the inductive, atheoretical search for regularities. Instead biology and the evolved content of the mind dealt with by psychology could be seen as grounded in an elegant set of evolutionary engineering principles that provide a causal explanation of how each species acquired its distinctive design. Biology was systematically transformed along these lines but psychology, which is much more central to our concept of ourselves, until recently remained well protected against darwinian insights.

For those in the social sciences and humanities unconvinced by dualism, a second line of defence against the darwinian synthesis proved more durable. For a century, the view has been widely accepted in these fields that virtually all human mental content derives from individual experience with the physical or social world. As Aquinas put it, there is "nothing in the intellect which was not previously in the senses". All adult mental content is considered to be acquired or constructed through the operation of general-purpose learning mechanisms that, like the parts of a tape recorder or a camera, impart no content of their own to the outcome. Human nature is viewed as Locke's "white paper, void of all characters" plus a capacity to learn culture, so nothing interesting about culture or social life can arise from human nature itself. Humans have indeed evolved but this is not significant because the human brain is a purged *tabula rasa*, a

blank slate that is ordered by the social and nonsocial environment. Within this framework, perception and an associationist metatheory of learning that has been perpetually unsuccessful (see Gallistel, this volume), became the central pre-occupation of psychologists and has been mirrored by neuroscientists.

Now, as this Workshop report makes clear, the barriers that had been vigorously defended for so long have all but collapsed. Comparing the institutionalized dismissals that were so well-entrenched when we two began to work on evolutionary psychology just two decades ago with the present intellectual climate emphasises that a conceptual revolution has gathered considerable momentum. The central insights that have made this conceptual shift possible can be summarized as follows:

- The mental is biological computation. The nature of the mental has been successfully determined and its relationship to the physical can now be precisely characterized and investigated. The mind is the computational architecture of the brain, implemented by physical arrangements of biological elements; aspects of these embody information and procedures that act on information. Hence, the physical and mental can be mapped back and forth between computational and neurobiological concepts, allowing the neural and cognitive sciences to interdigitate.
- Natural selection engineered the mind to carry out evolved functions. It is the only known creator of complex functional order in organisms, so the functional aspects of the mind and brain (as opposed to by-products or noise) were incorporated into the architecture of each species because they solved ancestral adaptive problems; for humans, they served biological functions for our hunter-gatherer ancestors. This means that selectionist theories and studies of hunter–gatherers can be used to identify design specifications for the functional units of the human brain and mind.
- The mind is not a blank slate or general-purpose computer but resembles a heterogeneous network of application programs for

specialized functions. Each program, device or module was tailored by selection to solve a particular adaptive problem, e.g., object recognition or avoiding incest, so each is endowed with a unique set of computational circuits appropriate for solving that problem — what might once have been termed innate ideas. The computational procedures required to perceive colours as constant regardless of the illumination are different from those required for sound localization, successful selection of a mate or motivating friendships. Moreover, these independent procedures require functionally specialized developmental programmes; as their processing goals are not the same, they could not be derived from any unitary superordinate physical process, such as the formation of associations.

The integration of evolutionary biology, biological anthropology, neuroscience and cognitive science thus provides the conceptual framework for reverse engineering the human neural and cognitive architecture (see Dennett, Pinker, this volume). The importance of this reaches far beyond the neural and cognitive sciences, because it establishes that the human mind has an evolved, content-inflected structure, rather than being an empty vessel into which arbitrary cultural elements flow from the outside. This, in part, shapes the content of culture and social interaction. Because the mind is not a blank slate, its complex species-typical architecture, which will eventually be mapped by neuroscience and psychology, has rich implications for the social sciences and humanities. The blueprints of this neural and cognitive architecture will be the centrepiece of future theories of culture, society and economic behaviour.

Plato and Kant thought that an innate structure is necessary for the human mind. The synthesis of the darwinian and cognitive revolutions provides a pivot for a rich, predictive account of how this innate structure came to be built into the mind. It will also help us specify what innate idea are likely to be in the human inventory. As Darwin wrote in his notebooks, "Plato

says... that our 'imaginary ideas' arise from the preexistence of the soul, are not derivable from experience — read monkeys for preexistence". Although what might be called the great conversation clearly started in the classical world with the emergence of philosophy, Darwin made this enquiry central to the scientific project. It is emblematic of the our new darwinian world that philosophers, biological scientists studying the brain and cognitive scientists studying the mind so naturally commingled at this Workshop. The next round of philosophy may well be written collaboratively by cognitive neuroscientists informed by evolutionary principles.