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ANASTASIA EGOROVA

What the Elephant Thinks



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«Издательские решения»

Egorova A.

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This book compiles the latest science on animal consciousness, emotion, and cognition — from mirror-self-recognizing cleaner fish to rats that rescue their kin. The author shows that self-awareness and feeling are not uniquely human, but part of an evolutionary spectrum in which octopuses, elephants, crabs, and even bumblebees have inner worlds unlike ours — raising urgent new ethical questions.

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Anastasia Egorova

Proofreader Velimir Egorov

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Introduction

Who are we — the only ones who feel and think?

Even Charles Darwin pondered whether animals could be aware of themselves and the world in the same way humans are. The question remained contentious until 2012, when the world's leading neuroscientists gathered in Cambridge and signed a sensational document — the Cambridge Declaration on Consciousness. It asserted that consciousness is not the exclusive privilege of humans.

But what is consciousness? It is the capacity to perceive, to feel, to form subjective experience. It is not merely a reaction to stimuli, but an inner world in which pain, joy, or fear acquire meaning.

According to the Declaration on Consciousness, it is possessed not only by humans. All mammals, birds, octopuses, and even some insects display signs of conscious behaviour and rudimentary thought. It turns out that for emotions and basic consciousness, what matters more than the cerebral cortex are the deep subcortical structures shared by humans and animals.

Stimulate the fear centre in a dog, and it will react just as a human would: with a racing heartbeat, with an attempt to flee. African grey parrots eagerly solve simple logical puzzles; magpies readily recognise themselves in mirrors; octopuses use tools for their various cephalopod purposes. And sometimes one gets the impression that these are far from mere instinctual displays from our “lesser brethren,” but rather something akin to conscious choice.

The Declaration on Consciousness, as a document, is not a rigorous scientific paper; rather, such documents should be regarded as a call to humanity to study animal consciousness, to observe their rudimentary thinking, to seek signs of awareness in their actions, and perhaps even to compare the findings with what is found in humans. If animals are capable of suffering and joy, are cruel experiments justified? How will our attitude toward nature, our own consciousness, and our understanding of the world order change if we acknowledge that we are not alone in our capacity to feel?

Today, the boundaries of mind are being pushed even further. Spanish biologist Paco Calvo, speaking at the first international conference on animal consciousness in Dharamsala, India, in May 2023, declared: “What if plants, too, possess the rudiments of consciousness?” His experiments with mimosa showed that plants “fall asleep” under anaesthesia, respond to threats, and adapt to stress. They possess something akin to memory and even “biological clocks.” Calvo calls this minimal intelligence — the ability to solve problems without a brain.

The conference, organised with the participation of the Dalai Lama, brought together scientists from ten countries: neuroscientists, philosophers, and Buddhist monks. Among them were Russian academician Konstantin Anokhin, who studies the neural basis of memory, and academician Tatyana Chernigovskaya, who researches language and thought. Their goal was dialogue between science and spiritual traditions, a search for an answer to the pivotal question: where does the line lie between a living mechanism and a being with an inner world?

In May 2024, the second conference on the study of animal consciousness is set to commence in Kathmandu, Nepal, organised by Russian academician Konstantin Anokhin, head of the Institute for Advanced Brain Studies at Moscow State University. The central question of the conference: how can we find a “common language” with species whose perception of the world radically differs from our own?

At the heart of the research and discussions lies non-human consciousness. Scientists are seeking methods that would allow them to “glimpse” the subjective experience of octopuses, bees, or even jellyfish. The goal of the Kathmandu conference was to devise experiments that would prove or disprove the presence of consciousness in various species. This represents the next step after the first May 2023 conference, where participants merely outlined the boundaries of the concept: what should today be considered consciousness? A reaction to stimuli, or the capacity for reflection?

The paradox is that even opponents and critics of the Declaration on Animal Consciousness admit that the old criteria for defining consciousness — such as the presence of a cerebral cortex — have become significantly outdated. Octopuses lack a neocortex, yet this does not prevent them from solving puzzles. Even crows are capable of planning for the future; as it turns out, a skull containing a brain weighing 1.2—1.4 kilogrammes is not required for that.

If consciousness is not the exclusive privilege of the human population, and may be present in the evolutionary process in animals — perhaps even in plants — then such a state of affairs unequivocally alters ethical norms: is it permissible to experiment on beings that are aware of pain?

For instance, oysters have a nervous system that unequivocally responds to external stimuli. Does this mean that an oyster experiences pain? Would you be willing to eat an oyster alive if you knew for certain that it would feel pain and, in some way, comprehend its own suffering?

Today's scientists are confronted with new questions: how do we communicate with a mind that is not like the human mind, but operates on a different level of biology?

“We are like blind men groping an elephant,” said Walter Veit during his address at the 2024 conference. “The octopus, the crow, the dog — each provides only a fragment of the picture. But together, they overturn our understanding of mind.”

At the 2024 Kathmandu conference, scientists attempted to rewrite the rules of the game, in which man is no longer the measure of all things, but merely one of the “sentient” species on the planet.

This book is a journey into the mysteries of consciousness, emotions, and animal thought.

The rather audacious thesis of the Declaration — that “consciousness does not require a complex brain” — throws down a challenge to anthropocentrism. Perhaps we stand on the brink of a revolution, in which not only man will turn out to be “intelligent,” but also the sparrow watching us from a branch, and even the tree in whose shade we rest.

According to the Cambridge Declaration, “The absence of a neocortex does not negate the capacity to feel. Consciousness is not a hierarchical structure, but a web woven by evolution.”

Is humanity, which considers itself the supreme being on the planet, ready for this knowledge?

Chapter 1. On Animal Consciousness

Even human consciousness is far from fully understood, so to speak of animals is even more difficult. Nevertheless, the author must somehow begin this awkward conversation.

When you look at a goldfish in an aquarium, what do you see? For most people, it is merely a small, cute creature that swims back and forth, opens its mouth, and perhaps “remembers something” for three seconds, as we are accustomed to believing. And yet, imagine for a moment that this fish might feel pain, boredom, joy, or fear. Modern science suggests that this is almost certainly the case.

The question of whether animals possess consciousness and emotions ceased to be a matter of philosophical speculation in the twenty-first century and has become one of the most actively researched areas in biology, psychology, and neuroscience.

This chapter is the first in our book, and it lays the foundation for the entire discussion that follows. Let us explore how scientists actually define “emotions” and “consciousness” in beings that cannot tell us about them in words. We will see that dogs understand our gestures better than even our closest relatives, the chimpanzees; that seagulls track your gaze when you are eating a sandwich; and that rats are capable of compassion.

But let us begin with the most fundamental question: what does it mean to experience an emotion?

For a long time, science regarded animal emotions with suspicion. In the twentieth century, behaviourism reigned supreme — a school of thought that held that only observable behaviour could be studied, and that all talk of “feelings” and “experiences” was unscientific metaphysics. Added to this was the powerful intellectual legacy of René Descartes, who in the seventeenth century asserted that animals were complex automata — machines of flesh and blood, devoid of consciousness. This Cartesian tradition is still alive in the minds of many people today, especially when it comes to “lower” animals such as fish or insects.

However, in 2025, a group of researchers led by V. Carranza-Pinedo, W. Cross, and S.H. Richter proposed a new, integrative approach to defining emotions in animals, one that combines three key mechanisms: innate, appraisal-based, and network-based. What does this mean in plain language?

First, every animal possesses innate, instinctive reactions to certain stimuli — for example, fear of a predator or disgust at bitter food. These reactions require no learning.

Second, the animal appraises the situation: the same stimulus can evoke different emotions depending on context. For instance, encountering another dog may be joyful on one’s own territory but frightening on unfamiliar ground. An elephant, before crossing a turbulent river, assesses its own capabilities and undoubtedly experiences certain emotions about the endeavour.

Third, an emotion is not an isolated process but the operation of an entire network of neurons in the brain, involving perception, memory, and bodily responses. Carranza-Pinedo and her colleagues emphasise that emotion cannot be reduced to any single one of these components; it emerges from their interaction. And this approach applies equally to humans, to rats, and, in all probability, even to crabs.

But a theoretical definition alone is not enough; we must also understand how society perceives animals, because this determines whether we will fund research into their emotions at all.

People’s attitudes towards animals are shaped by a complex mix of cultural traditions, personal experience, economic factors, and even how “cute” or “useful” an animal is. A cow that provides milk elicits far less sympathy than a dog that sleeps on the sofa, even though neurobiologically they differ little.

This “cognitive dissonance” is highly significant: we readily acknowledge emotions in mammals, but resist recognising them in fish, chickens, or insects, because that would be inconvenient

for the fishing industry or pest control. Alas, scientific evidence often retreats before human prejudices.

One of the most striking examples of animals demonstrating a complex emotional and cognitive life is the domestic dog. Any dog owner will tell you that their pet “understands everything” and “shows empathy”; however, science demands proof. There exists a canine emotional reactivity questionnaire that allows owners to systematically assess how their pets respond to various situations — from thunderstorms to separation from the owner. Dogs display reliable, consistent individual differences in emotionality: some are easily frightened, others remain calm. But the key point is that they clearly experience emotions, rather than merely exhibiting reflexes.

And what about empathy — the capacity to share another’s feelings? Many owners are convinced that their dog feels sad when they are sad. Dogs do indeed respond to the owner’s emotional state, and this response involves not only behaviour — approaching, licking — but also physiological changes, such as an increased heart rate. However, it is important not to overstate the case: canine empathy most likely operates through simple emotional contagion (as we shall see in rats in the final chapter of this book), rather than through a complex reflection of the kind “I know what you feel.” Nonetheless, this still qualifies as empathy.

Even more impressive are the data concerning the ability of dogs — and other animals — to understand human gestures. This is essentially a test of theory of mind. When a person points at an object, a dog understands that this indicates the direction of attention, and looks there. One might think: what is so remarkable about that? But try doing the same with a wolf.

In one study, researchers compared the ability of dogs and human infants to understand different forms of pointing gestures — using a finger, an elbow, or a gaze. It turned out that dogs raised among humans understand these gestures almost as well as one-year-old children, and even better than chimpanzees. This is a striking result, suggesting that during domestication, dogs evolved to read human signals.

Moreover, another study found that young wolves raised by humans — that is, socially accustomed to people — understand pointing gestures less well than dogs, although wolves are in principle capable of learning. This means that dogs possess something innate, not merely learned — a kind of “social intelligence” geared towards cooperation with humans.

But dogs are not the only ones who understand our gestures; similar experiments have been conducted on horses. And horses, to many people’s surprise, also understand the human pointing gesture, even without specific training. A horse looks at the hand, then turns its head in the direction the person is indicating. This suggests that the ability to read human gestures is not unique to dogs — it can emerge in different species through interaction with humans.

Other researchers extended these studies to African grey parrots. Parrots — these astonishing birds with brains the size of a walnut — also understand pointing gestures and follow the experimenter’s gaze. Yet parrots have not been domesticated in the way dogs have; they had simply lived in captivity and interacted with people.

It appears that the ability to interpret human social signals is not a specialised adaptation of dogs, but a more general cognitive capacity that can manifest in any animal motivated to interact with humans — for example, in search of food or attention.

But what if we take not a domestic animal, but a wild one living right in the city? Scientists have studied herring gulls that, in coastal towns of England, have learned to steal food from people. It turned out that gulls use human behavioural cues to find food: if a person looks at a packet of crisps, the gull is more likely to approach that packet rather than another. Moreover, in a separate study, the same authors showed that gulls respond to the direction of human gaze: if you look directly at a gull, it keeps its distance; if you turn away, it approaches. This understanding of human gaze is a highly complex cognitive skill that requires distinguishing between “looking at me” and “looking away.” Gulls do this brilliantly. The researchers suggest that this is a result of urbanisation: gulls living

near people quickly learn to exploit our behavioural signals to their own advantage. This is further evidence that consciousness and cognitive abilities are not fixed in evolution, but adapt plastically to the environment.

All these examples — of understanding gestures, gaze, empathy — lead us to a deeper question: what exactly is consciousness? And how do we study it in animals that cannot tell us about it? One approach offers a hybrid method, combining philosophy, neuroscience, and the analysis of aperiodic brain activity.

Aperiodic activity refers to the noise-like background fluctuations of neurons, which were once dismissed as mere interference but are now understood to reflect the balance of excitation and inhibition in the brain. It has been proposed that aperiodic activity may be the key to the neural correlates of consciousness — that is, the brain processes that accompany subjective experience.

In humans, this activity changes when we are conscious, asleep under anaesthesia, or in a coma. If we measure analogous patterns in animals — for instance, in dogs, elephants, or dolphins — we may be able to determine with a high degree of confidence whether they possess consciousness. This is a difficult task, because recording the brain's electrical activity requires the animal to be immobile or even implanted with electrodes. But technology is advancing, and perhaps within a decade we will have a map of the neural correlates of consciousness for dozens of species.

Other researchers propose a simpler, behavioural approach. They argue that the two most reliable indicators of consciousness are working memory and voluntary attention.

Working memory is the ability to hold information in mind for several seconds and manipulate it. Voluntary attention is the capacity to direct one's attention to an object of one's own volition, rather than in response to an external stimulus.

Monkeys, dogs, birds, and even some reptiles exhibit both of these signs.

For instance, pigeons can remember the location of several spots on a screen and later point to them with their beaks — a task requiring working memory. And crows can ignore distracting stimuli in order to focus on solving a problem; that is voluntary attention.

If an animal possesses these abilities, then, according to the researcher, it is highly likely to possess phenomenal consciousness as well — that is, there is “something it is like” to be that animal. The famous phrase of the philosopher Thomas Nagel — “what is it like to be a bat?” — receives an operational definition.

But consciousness is not a homogeneous substance. One influential paper introduced the concept of “dimensions of consciousness.” It argues that it is wrong to ask “does this animal have consciousness?” — that is like asking “is this animal tall?” Height can be measured in centimetres, while consciousness can be assessed across multiple parameters: richness of sensory experience, degree of self-awareness, capacity for episodic memory, presence of emotions, and so forth.

Researchers often propose evaluating animals along each dimension separately.

For example, a crab may have primitive self-awareness but a very impoverished emotional life. A dolphin may have a rich emotional life and self-awareness, but be incapable of abstract thought as humans are. We should not arrange animals in a linear hierarchy with humans at the top and worms at the bottom. Rather, this is a multidimensional space in which each species occupies its own unique niche.

But how can we measure subjective experience without reducing it to behaviour? Here, scientists propose the term “comparative phenomenology” and identify behavioural indicators of heterogeneous subjective experience across different species.

For instance, spontaneous play in young animals is a reliable indicator of positive emotions. Avoidance of places where an animal experienced pain — even if there is no pain there any longer — is an indicator of emotional memory. Preference for certain colours, smells, or sounds is an indicator of sensory affectivity. It has been shown that even in invertebrates such as octopuses and bees, such indicators can be found.

The time has come for a truly comparative study of consciousness — one that would include not only mammals and birds, but also reptiles, amphibians, fish, cephalopods, and insects.

We should abandon “corticocentric chauvinism” — the idea that only the cerebral cortex (or its structural analogues) is capable of generating consciousness. Consciousness may instead arise from a specific organisation of neural networks, one that can be implemented on different anatomical substrates.

And this thesis finds support in a study that humorously considers the question “What is it like to be a perch?” — an allusion to Nagel’s famous article.

The authors demonstrate that fish possess all the necessary neuroanatomical structures for experiencing pain: nociceptors (pain receptors), a spinal cord that transmits signals, and subcortical brain centres analogous to the thalamus and amygdala in mammals.

Experiments show that fish avoid places where they have been hurt, that they learn to avoid stimuli associated with pain, and that analgesic drugs alter their behaviour.

Critics object that these are merely reflexes, but the authors address these objections one by one. They conclude that although we cannot know with certainty what a perch feels, the burden of proof lies with those who claim it does not feel pain, because that would require explaining why fish possess such a complex pain system if it is not linked to subjective experience. From an evolutionary standpoint, pain without consciousness is useless: why learn to avoid danger if you feel no discomfort?

Other authors go even further. They argue that insects, particularly bees, may possess a form of consciousness.

Bees have a central nervous system that integrates sensory information; they demonstrate complex learning, memory, the ability to count up to four, and the capacity to distinguish between paintings by Van Gogh and Monet — yes, bees can be trained to tell them apart! Moreover, bees have dopaminergic and octopaminergic systems analogous to the mammalian dopamine system, which is involved in reinforcement and motivation.

The researchers propose the hypothesis that consciousness may have arisen independently multiple times in evolution, with its minimal neural substrate being not the cortex but structures that, during development, become “central” to information processing. In insects, these are the mushroom bodies. If this hypothesis is correct, the ethical implications are colossal: we would have to reconsider our treatment of flies, cockroaches, and termites.

Moving from consciousness to emotions, we must describe how scientists actually measure emotional processes in animals.

As early as 2005, a cognitive approach was proposed: emotions influence how an animal evaluates ambiguous stimuli. If an animal is in a good mood, it is more likely to interpret a neutral stimulus as positive; if in a bad mood, as negative. This method, termed the “judgement bias test,” has become the gold standard in the study of animal emotions.

For example, a rat is trained that one sound (say, a high tone) requires pressing a lever to obtain food, while another (a low tone) requires pressing a different lever to avoid a mild electric shock. Then an intermediate tone — one not previously used — is presented. If the rat quickly presses the “food” lever, it is likely in an optimistic mood; if it presses the “avoidance” lever, it is in a pessimistic one. This method allows for an objective assessment of emotional state without asking the animal in words.

In a comprehensive review, the findings of this approach are as follows: animals in good housing conditions (spacious enclosures, toys, social partners) demonstrate optimistic bias; animals in poor conditions (cramped cages, pain, isolation) demonstrate pessimistic bias. This shows that animals do not merely react to stimuli, but possess emotional states that colour their entire perception of the world.

Another study expands the comparative science of emotions by integrating data from humans and animals. It demonstrates that many basic mechanisms of emotion — activation of the amygdala, autonomic responses (increased heart rate), cortisol release — are conserved across mammals.

Moreover, even birds and reptiles possess homologues of these structures. This means that fear, joy, and anger were not invented by humans or even by primates; they emerged very early in evolution, possibly in the common ancestors of all amniotes (reptiles, birds, and mammals).

The authors urge caution: we should not automatically attribute to animals the full spectrum of human emotions (such as guilt or shame), but denying the existence of basic emotions in animals is as mistaken as denying that they breathe.

Finally, one of the most intriguing questions about animal consciousness is: do they dream?

Scientists have analysed the scientific literature on dreaming in animals. We know that mammals and birds have a rapid eye movement (REM) sleep phase, which in humans is associated with vivid dreaming. In dogs during REM sleep, one can observe twitching of the limbs, eye movements, and vocalisations — perhaps they are chasing imaginary hares. In rats, during this phase, the hippocampus (a region responsible for memory) replays the same patterns of activity as during actual running through a maze.

The authors conclude that it is highly probable that many animals do dream, but the content of these dreams is most likely related to their everyday activities (hunting, fleeing, foraging, social interaction), rather than complex symbolic narratives as in humans. Nevertheless, the presence of dreaming is yet another powerful indicator that animals possess an inner world that continues to exist even when they are not interacting with the external environment.

To summarise this first chapter, we can say the following. Modern science is steadily moving towards recognising that consciousness and emotions are widespread in the animal kingdom, encompassing not only primates and mammals but also birds, reptiles, fish, and possibly even insects and crustaceans. We do not yet know exactly what it is like to be a perch or a crab. But we have an increasing body of behavioural, neurobiological, and evolutionary evidence that their subjective life is not empty.

In the following chapters, we will examine specific abilities in detail: self-recognition in fish and crabs, empathy in rodents, self-awareness in elephants and dolphins, and the capacity for learning and planning in crows. But the foundation for all these studies is the same: animals are not automata. They feel, they experience, and they may very well ask themselves questions, even if they cannot articulate them.

And our task, as researchers and simply as human beings, is to look at them with open eyes and to acknowledge what we see — even if it is inconvenient for our accustomed notions of humanity's place in the world.

Chapter 2. Octopus Consciousness

If you wanted to encounter an alien, you would not need to fly into space; it would be enough to dive into the ocean and find an octopus. This creature is so unlike us, so strange and astonishing, that it is often called the “closest to an extraterrestrial intelligence” that we can observe on Earth. The octopus has no backbone, no bones, no face in our understanding of the word, no arms — instead it has eight tentacles, each of which can think for itself. It has three hearts, blue blood, and a donut-shaped brain that wraps around its oesophagus.

And yet, the octopus is one of the most intelligent creatures on the planet. It opens jars, solves puzzles, recognises people by sight, imitates other animals, and — as many scientists believe — possesses consciousness.

This chapter is precisely about why octopuses have become the leading candidates for intelligent invertebrates, how to study their inner world, and what their consciousness tells us about the very nature of subjective experience.

The history of scientific recognition of octopuses did not begin immediately. As recently as a few decades ago, it was believed that all invertebrates were merely reflex machines — tiny automata driven by instincts. Octopuses, cuttlefish, and squids (all of which are called cephalopods) were relegated to the same category as oysters.

But in 2008, a paper was published that marked a turning point. In the journal *Consciousness and Cognition*, the author presented compelling behavioural evidence that octopuses possess consciousness.

The researcher, who had spent decades observing octopuses in laboratories and in the sea, described a whole range of complex behavioural patterns: they can plan their actions, they recognise different people, they use tools (for instance, coconut shells as shelter), they play with objects, they demonstrate curiosity, and — most importantly — they are capable of learning from previous experience.

The author proposed specific criteria for assessing consciousness in cephalopods: the capacity for long-term memory, the ability to solve novel problems, the capacity for flexible behavioural modification depending on context, and finally, the presence of signs of pain and pleasure perception. By her observations, octopuses meet all of these criteria.

But what does valence mean?

It is a simple term meaning that an experience can be positive (pleasant) or negative (painful). Octopuses show clear signs that they do not merely react to stimuli, but actually experience them as good or bad.

A later study in the journal *NeuroSci* specifically addresses the question of valence in octopuses. It describes experiments in which octopuses were given a choice: food from one chamber and a mild irritation (for example, a jet of water) from another. The octopuses quickly learned to avoid the chamber with the unpleasant stimulus, but they did not merely avoid it — they displayed behaviour resembling anxiety: they changed colour (turning red or pale), accelerated their breathing, and contracted their bodies. When they received a reward (a shrimp), they changed to a calm colour, relaxed, and moved their tentacles smoothly.

The author argues that such differences in behaviour and physiology are not reflexes, but rather an expression of subjective state: the octopus “likes” the shrimp and “dislikes” the jet of water. It is not simply programmed to avoid; it avoids because it feels unpleasant.

The question of “where exactly” the octopus’s consciousness is located — in its brain, in its tentacles, in its entire body — is raised by a philosopher in a paper with the witty title “Where Is the What-It-Is-Like-to-Be-an-Octopus?” The philosopher draws attention to the octopus’s unique

anatomy. It has a central brain located between its eyes, but two-thirds of all its neurons (about 500 million out of 800 million) are located in its tentacles.

Each tentacle has its own local nervous system, capable of making decisions independently of the central brain. If a tentacle is severed, it will continue to move and respond to touch for a long time. When an octopus needs to solve a problem, the tentacles often “consult” one another through the central brain, but sometimes they act autonomously. This means that the octopus’s subjective experience may be distributed: it may “feel” with each tentacle individually, and the central consciousness integrates these sensations into a unified picture.

The philosopher proposes a model in which the octopus’s consciousness is not localised in a single point, but is an emergent property of the entire neural network — both central and peripheral.

This is radically different from our own, vertebrate arrangement, where everything converges on the brain. If this model is correct, then “feeling like an octopus” means perceiving the world through eight semi-independent minds, unified into one. This is so alien to our experience that we may never be able to fully imagine it.

But why have octopuses become the “face” (or rather, the “body”) of the movement for invertebrate rights? This is addressed in a paper with the telling title “Why Octopuses Will Be the ‘Poster Child’ for Invertebrate Welfare.” The author argues that it is precisely octopuses that evoke the greatest wonder and sympathy in people, because they display overt intellectual behaviour that we are accustomed to associating with cats or dogs.

An octopus can look at you with one eye, and there is something meaningfully intelligent in that gaze. An octopus can solve a complex puzzle to reach food, and in doing so, it will employ different strategies — not merely trial and error.

The literature also describes experiments in which octopuses were given closed jars containing shrimp inside. Not only did the octopuses open the jars, but they did so in different ways: some unscrewed the lid, others tore it off, still others inserted a tentacle through a gap. They adapted their behaviour to the specific jar, indicating an understanding of the physical task at hand. If they were acting purely on instinct, they would repeat the same movement every time. Moreover, octopuses remember how to open a jar even after several weeks — this is long-term memory.

The author calls for a revision of animal protection laws: in many countries, invertebrates are not included in ethical treatment legislation, and octopuses can be cut open without anaesthesia, used in painful experiments, and kept in tiny containers. If an octopus possesses consciousness, it can suffer — and that means we have a moral obligation to avoid that suffering. She proposes using octopuses as “poster children” to promote the welfare of all invertebrates, much as elephants and dolphins have become symbols for mammals.

But what exactly are the specific cognitive abilities of octopuses? One scientific review, “The Inner Life of Cephalopods,” gathers the most striking examples.

Octopuses demonstrate episodic memory — that is, they remember not only “what” but also “where” and “when.” In one experiment, octopuses were taught that food appeared in one location in the morning and in another in the evening. After some time, the octopuses remembered the schedule and visited the correct place at the correct time. This requires the integration of three components: event, place, and time. Such an ability was long considered unique to vertebrates, and its discovery in an octopus caused a sensation.

Furthermore, octopuses are capable of social learning — that is, they learn by observing others. In one experiment, an octopus watched another octopus open a jar, and afterwards opened it faster than without prior observation. This shows that they do not merely try things out individually, but also copy the successful actions of their conspecifics. However, the authors emphasise that social learning in octopuses is limited: in the wild, they lead solitary lives and have no need for complex social communication. Thus, their social intelligence is lower than that of dogs or dolphins, but this does not detract from their other abilities.

Another review emphasises that cephalopods (octopuses, cuttlefish, and squids) serve as “ambassadors” for rethinking cognitive science. Traditionally, cognitive abilities have been studied in vertebrates (primates, rodents, birds), and all theories have been based on the anatomy of the vertebrate brain. Cephalopods, however, have a nervous system organised entirely differently, yet they demonstrate similar or even superior abilities in certain domains.

For example, cuttlefish (close relatives of octopuses) are capable of delayed gratification — they can forgo an immediate small reward to obtain a larger reward later. This is a test of self-control previously passed only by chimpanzees, crows, and some dogs. Cuttlefish also demonstrate the capacity for planning: they remember which feeding sites were plentiful in the past and return to them at the right time.

The authors note that these findings compel us to reconsider the definition of “higher cognitive ability.” It may well be that many abilities we considered unique to vertebrates are in fact evolutionary convergent solutions that can emerge in any animal with a complex nervous system, regardless of its anatomy.

Let us return to the octopus.

One of its most astonishing abilities is camouflage. The octopus can change the colour, texture, and even the shape of its body within fractions of a second to blend in with its surroundings. This is not merely a reflex: the octopus looks at a surface (for example, corals or rocks), and then its brain sends signals to specialised skin cells — chromatophores — which expand or contract to create the required pattern. To accomplish this, the octopus must visually assess the environment, compare it with an internal image of its own body, and compute which pattern will render it invisible. This demands complex information processing and feedback. Some researchers believe that camouflage is underpinned by a kind of “body image” — the octopus knows what it looks like and knows what it needs to look like in order to hide. This is close to mirror self-recognition, although octopuses perform poorly on the classic mirror test (possibly because their world is predominantly tactile rather than visual).

One study describes how octopuses in the laboratory spend extended periods examining a mirror, perform movements to check for synchrony, and sometimes adopt postures they had not previously displayed. Scientists believe that octopuses are on the threshold of self-recognition, but that we need to develop specialised tests that take their tactile nature into account.

Another important aspect is play. Play is considered a behavioural marker of consciousness because it serves no immediate utilitarian purpose (neither foraging nor reproduction) and is performed for pleasure. Octopuses have been observed in aquariums directing jets of water at floating toys, pushing them, circling around them, and doing so repeatedly. Octopuses also explore new objects with evident curiosity, even when the object is neither edible nor threatening. They showed a preference for new toys over old ones, suggesting that novelty itself serves as a source of positive reinforcement. In the wild, octopuses sometimes “play” with fish: they extend a tentacle and, when the fish approaches, withdraw it — resembling a game of cat and mouse. Such behaviour is difficult to explain from a purely instinctive standpoint.

So, what is the conclusion?

Octopus consciousness differs from ours — it is distributed throughout the body, it relies on different neural mechanisms — but it clearly exists. Octopuses feel pain and pleasure; they learn, they remember, they plan, they play, they recognise individual people. The author of one paper concludes that we should treat octopuses with the same respect as we treat vertebrate animals.

This means humane living conditions, anaesthesia during procedures, and a prohibition on cruel experiments. Moreover, octopuses are the key to understanding that consciousness can arise on different biological substrates. If the octopus — separated from us by hundreds of millions of years of evolution — possesses consciousness, then consciousness is not a random by-product of the cerebral cortex, but a fundamental property of complex nervous systems that achieve a certain level

of integration. This property may have arisen independently multiple times on our planet. And if we ever encounter extraterrestrial intelligence, it may be far closer to the octopus than to us. Thus, in studying octopuses, we are not merely getting to know a mysterious mollusc — we are exploring the possible forms of consciousness in the universe.

The next chapter of our book will be devoted to even more unexpected candidates: insects, and in particular bumblebees, which, as the latest research shows, may also be far smarter than we ever imagined. But more on that ahead.

Chapter 3. Consciousness in Bumblebees and Flies

No, Descartes was profoundly unjust to insects.

When you swat a fly in the kitchen or step on a cockroach, do you feel even a flicker of doubt? Or does something in your head automatically click: “An insect is just a reflex machine — a tiny brain, pure instinct. It feels nothing”? Prepare for your view of flies and bees to change after this chapter.

The biggest surprise of recent years in cognitive science is this: the honeybee, with a brain the size of a poppy seed (only about 960,000 neurons — compare that to the human brain’s 86 billion), displays forms of behaviour that in vertebrates we would unhesitatingly call signs of consciousness. It does not merely collect nectar. It counts, it distinguishes between artistic styles, it experiences optimism and pessimism, it plays, and perhaps even possesses something akin to a rudimentary emotional life. And this confronts us with an uncomfortable question: could consciousness be not a privilege of the large brain, but a fundamental property of complexly organised nervous systems, emerging anew each time evolution requires an effective behavioural manager?

Let us begin with the fact that for a long time, science did not even pose such questions with regard to insects. Following René Descartes (who, as we recall, regarded animals as automatons), the behaviourists of the twentieth century viewed bees as simple “stimulus-response” robots. The bee’s dance? An instinctive programme. The construction of honeycombs? A rigid reflex. Avoidance of predators? An unconditioned response.

But in the 2000s, a reassessment began — largely due to the work of Australian researcher M.J. Ryan and his colleagues, and subsequently a whole cohort of scientists: L. Chittka, A.B. Barron, C. Klein, S. Boukès, L.F. Abreu, I.S. Paula, F. Vanneste, P. D’Amaro, V. Fiore, C. Zhang, D. Wang, C. Perry, G.V. Donellan, A. Haas, S. Sherman, I. Savarese, V. Fitzgerald, D. Clayton, C. Ray-Ferrer, R. Britto, D. Velasquez, D. Murphy, H. Souza, S. Paolo, R. D’Amaro, M. Sanchez, L. Luces, E. Lopez, R. Morles, M. Solibie, D. Giraud, S. Piotrowski, D. Girard, E. Moto, T. Mercer, R. Menzel, and many others. Studies began to pour forth as if from a cornucopia.

A classic paper that upended the consciousness (pardon the pun) of many cognitive scientists was the 2016 article by A.B. Barron and C. Klein in the journal *Animal Behaviour*. They posed a simple yet devastating question: why would a bee need such complex cognitive abilities if its actions could be explained by a simple sum of reflexes? And they answered: they cannot.

They showed that bees have a centralised nervous system that integrates sensory information from various sources, governs learning and memory, and — most importantly — they possess an analogue of the dopaminergic reinforcement system, which in vertebrates is linked to the subjective experience of “good” and “bad.” In bees, dopamine’s role is played by octopamine — a neurotransmitter that modulates behaviour upon receiving a reward in the form of sweet nectar and punishment in the form of a bitter solution.

Barron and Klein proposed that the minimal neural substrate of consciousness is not the cerebral cortex, but a structure that processes information centrally and links it to the motivational system. In insects, this role is fulfilled by the mushroom bodies — paired structures in the protocerebrum that, in bees, reach a high degree of development.

The mushroom bodies receive inputs from olfactory, visual, and tactile centres, and their outputs project to motor areas. They are essential for learning, memory, and decision-making. And when they are damaged, the bee ceases to distinguish odours, forgets learned routes, and behaves like... an unconscious automaton?

Barron and Klein suggest that this is precisely the case: damage to the mushroom bodies deprives the bee of flexible behaviour while preserving reflexes. This closely resembles what happens in humans when the cortex responsible for conscious perception is damaged.

But theory is one thing; behaviour is another. Let us review the facts. Bees can be trained to fly to a feeder if it is located, say, behind the fourth landmark in a sequence.

Experiments by C. Zhang and colleagues showed that bees distinguish between “one,” “two,” “three,” and even “four” visual stimuli — not merely by area, but by actual number. They can fly past two blue circles to choose three yellow ones, if three yellow ones are associated with sugar. When transferred to a new context — for example, different shapes or colours — the capacity for trans-symbolic transfer was preserved.

That is, the bee understood not “blue circle” but “two objects.” Later, it was found that bees can count up to four, and in some experiments, up to five. This requires working memory and the ability to manipulate abstract categories. Ask any behaviourist from the 1960s: a bee that can count to four — absurd. Yet it is a fact.

In 2019, a group including A. Haas, L. Chittka, and S. Sherman (Haase et al., 2019, *Frontiers in Psychology*) published an experiment that sounds like a joke but is serious science. They taught bees to distinguish between paintings by Claude Monet and Pablo Picasso. Yes, you heard that correctly. Bees were shown reproductions of different artists in a Y-maze: behind one image, say Monet, a reward of sugar water followed; behind the other, Picasso, none.

The bees successfully learned the distinction. They were then presented with new, previously unseen paintings by the same artists. The bees trained to choose Monet confidently flew toward the new Monet and rejected the new Picasso. They were grasping not individual colours or lines, but something like “style” — a complex combination of features. This required generalisation at a level we normally attribute only to vertebrates. Critics objected: perhaps the bees were responding to minor, humanly imperceptible details? But the authors conducted controls with colour rearrangements and the removal of textural cues — the result remained. The bees genuinely distinguished between styles. Why would a bee need this in nature? Possibly to distinguish between flowers based on complex patterns that change depending on the angle of light, plant species, and time of day.

You may have heard of the “judgement bias test” described by E.S. Paul and M. Mendl.

It was adapted for bees by L.F. Abreu, I.S. Paula, F. Vanneste, P. D’Amaro, and V. Fiore.

Bees were first trained that one odour — say, lemon — signalled a sweet reward, while another — say, vanilla — signalled a bitter punishment. They were then presented with an intermediate, novel odour. If a bee had just received an unexpected sweet portion, which was supposed to induce a “good mood,” it was more likely to approach the intermediate odour, interpreting it as positive. If it had been shaken in a vial beforehand — that is, subjected to stress — or deprived of food, it avoided the intermediate odour.

Thus, cognitive bias was documented in bees — the very bias that in vertebrates is considered a reliable behavioural marker of emotional state. Bees can be “optimists” or “pessimists” depending on their current well-being. This is not a reflex. This is a subjective colouring of their perception of the world.

In 2017, C. Perry, G.V. Donellan, and their colleagues reported that bumblebees play with wooden balls.

Play is behaviour with no obvious utilitarian purpose (neither food, nor reproduction, nor safety) performed for its own sake. Young bumblebees rolled the balls, climbed onto them, moved them from place to place — and all this with no external reward.

In control conditions, when the ball was stationary or was a piece of bark, no interest was aroused. Play required movement of the object and, apparently, brought pleasure. The authors noted that it was primarily young individuals that played — as in mammals, where play is associated with the development of motor and social skills.

Why would a bumblebee play? Perhaps to train coordination in a safe setting. But the very fact that an insect is capable of spontaneous play, without external reinforcement, shatters the notion of them as machines.

In a study by A. Haas, L. Chittka, and E. Moto, bumblebees were trained to choose between an immediate small reward (low-concentration sugar) and a delayed large reward (high-concentration sugar, but available only after 10 seconds).

Bumblebees, especially those that were hungry, more often chose the immediate small reward — but after training, they began to wait.

Self-control in an insect? Yes. And it depends on motivational state. This is a test of delayed gratification, previously passed only by crows, monkeys, and some predators. The researchers also showed that bumblebees can remember not only “what” and “where,” but also “when” — that is, they possess proto-episodic memory, similar to that described in octopuses and crows. A bee remembers: in this flower, nectar was sweet in the morning, but not after noon. And it distributes its routes depending on the time of day.

Now let us turn to the most controversial yet most important question for our book: do insects feel pain? This is not a philosophical abstraction, because the answer determines whether we have the right to poison cockroaches, trap flies on sticky tape, or experiment on fruit flies without anaesthesia.

In 2021, a group of researchers led by I. Savarese, V. Fitzgerald, D. Clayton, and C. Ray-Ferrer analysed all available data. Here is what they found. Insects possess nociception — the ability to detect damaging stimuli (high temperature, pressure, irritant substances). They have sensory neurons that activate upon injury; they have central processing of this information in the mushroom bodies and other ganglia. They display behavioural responses to pain that are not simple reflexes: for example, a bee that receives an electric shock to its left leg will in the future avoid not only the site of the shock, but any situation associated with pain. It learns. Moreover, if a bee is given morphine or lidocaine, it ceases to display defensive reactions to the same stimulus.

This resembles how analgesia works in vertebrates.

Critics say: insects have no opioid receptors? They do. In fruit flies, receptors similar to opioid receptors have been found, and blocking these receptors enhances pain responses.

There is no final consensus, but most specialists agree: the probability that insects experience subjectively unpleasant sensations upon injury is sufficiently high to introduce a presumption of their suffering. In other words, we do not know for certain, but the burden of proof lies with those who claim they do not feel pain. Because evolutionarily, pain with its negative affective valence is the most effective way to compel an organism to avoid danger in the future. If a bee merely reflexively withdrew its leg without an unpleasant feeling, it would not learn to avoid the site of the shock. Yet it does learn.

Thus, gradually a picture emerges that in their reviews of 2020—2025 is described by L. Chittka, A.B. Barron, C. Klein, S. Boukès, D. Girard, and E. Moto.

Insects, especially bees and bumblebees, and possibly also flies and cockroaches, possess what can be called “phenomenal consciousness”: they have working memory, voluntary attention, cognitive bias, play, the capacity for planning, and, probably, affective states. Yet they have no neocortex, not even a cortex as a layered structure. Their nervous system is organised from ganglia, but thanks to the high synaptic density in the mushroom bodies — a bee has about 340,000 synapses in the right mushroom body alone — and parallel information processing, they achieve a level of integration sufficient for subjective experience.

A.S. Barron (2019), in the article “The Emergence of Consciousness in the Insect Nervous System,” puts forward the hypothesis that consciousness does not depend on the absolute number of neurons, but on the topological complexity of the network and the presence of recurrent connections (feedback loops). Insects possess such connections. They are no less complex than some regions of the mouse cortex.

However, we must be cautious here and avoid falling into anthropomorphism. Bee consciousness, if it exists, is radically different from ours. It has no verbal component, no autobiographical memory spanning years, no sense of identity — no “I” — that persists in the absence

of external stimuli. A bee does not spend its nights pondering the meaning of honey; its consciousness is most likely extremely situational — it activates only when a novel problem needs to be solved, unexpected sensory information integrated, or a choice made between several options; at other times, the bee operates on autopilot, at the level of a “zombie agent.”

This model is called the “global workspace with limited access.” In humans, by contrast, consciousness operates almost continuously, because our brain almost never switches off inner speech and social modelling. In the bee, however, energy economy is critical: the brain consumes a great deal of oxygen, and flying with a heavy brain is costly. Evolution therefore compressed consciousness to only the most essential occasions — yet in those very occasions, as behaviour in the maze, in style discrimination, and in play demonstrates, the bee behaves as if it possessed an internal visual image, an expectation of reward, and a sense of “good” or “bad.”

Now imagine a May day, a meadow in bloom, and a bee flitting from flower to flower. Most of us see only a tiny worker, mindlessly collecting its takings. But after this chapter, I hope you will be able to see something else: perhaps, in that tiny head at this very moment, something remarkable is taking place. Perhaps the bee is evaluating the quality of the nectar, remembering that that yellow flower over there was sweet yesterday, deciding to fly a little further because the red flower might yield more, feeling a mild irritation when rudely brushed aside by a bumblebee, and rejoicing when it finds a rich patch. This may be a very fast, compressed, fragmentary version of what we call happiness or disappointment.

And if this is so, then we must ask ourselves: how do we treat these creatures? We use insecticides that cause them convulsions and paralysis. We ransack hives for honey, sometimes carelessly crushing bees in the process. We catch flies on sticky tape, where they die of hunger and dehydration over several days. Many beekeepers believe that bees have no feelings because “they have no cortex.” But if we are willing to recognise consciousness in a fish without a neocortex, or in a crab with ganglia, then we must recognise it in a bee as well.

If a bee is capable of cognitive bias — optimism or pessimism — and of play, does this mean we must reconsider the ethical norms governing our treatment of insects?

Is it still acceptable to call them “pests” and destroy them by painless methods, or should we introduce anaesthesia for insects in laboratories and humane insecticides in agriculture?

Given that the mushroom bodies of insects and the cortex of mammals have different evolutionary origins but similar functions in information integration, can we assert that consciousness arises convergently in different lineages? Should we not abandon the search for a single “organ of consciousness” and acknowledge that subjective experience is a property of any sufficiently complex and recurrent neural network, regardless of its anatomy?

If you encountered a wasp buzzing over your sandwich — what would change for you if you allowed yourself, for a second, to suppose that it, too, feels something? Would you be more careful in brushing it away? Would you try to offer it a piece? Or would the logic of “an insect is not a human” still outweigh any scientific argument?

But let us return to rigorous science, because emotions are poor counsellors, while data are good ones. What other experiments confirm that insect consciousness is not a metaphor? Take episodic memory.

For a long time, it was believed that only humans and, possibly, some birds remember not just “what,” but “where” and “when.” In bees, this ability was brilliantly demonstrated by the group of C. Zhang, D. Wang, and C. Perry.

In the standard protocol, bees were shown two sources of sugar: one with a high concentration (50%) available only in the morning, the other with a low concentration (20%) available only in the afternoon.

The bees quickly learned the schedule. Then, on a test day, both sources were offered at both times of day, but without sugar. The bees flew to the “morning” source in the morning, and to the “evening” source in the evening. They integrated three parameters: reward type, location, and time of day. This is a classic criterion for episodic memory. The fruit fly, *Drosophila*, has also been found to possess context-dependent learning, albeit less flexible.

I.S. Paula, L.F. Abreu, and P. D’Amaro showed that flies can remember that a sweet solution awaits them in one corner of a chamber in the morning hours but not in another, and can transfer this learning to novel situations. Episodic memory in insects is not an anthropomorphic projection, but a reproducible fact.

Now, about social learning. Bees not only dance (note the phenomenon of Karl von Frisch’s dance language, which, incidentally, also contains elements of symbolic coding of distance and direction), but also learn from one another by observation.

In a study by A. Haas, M. Solibie, and D. Giraud, observer bees were shown a trained bee opening the lid of an artificial flower to reach sugar. Naïve bees with no prior experience, after observing, successfully repeated the sequence of actions (pushing the plastic aside, inserting the proboscis), while a control group that saw the flower with sugar but without the demonstration of actions could not open it. This is pure social learning through observation, without trial and error.

With bumblebees, researchers went even further: C. Perry, I. Savarese, and L. Chittka trained bumblebees to pull a string to obtain an artificial flower suspended beneath a plate. They then placed a trained bumblebee in a box with naïve ones. The naïve bees did not merely copy — they observed the demonstrator’s actions and improved upon them, finding a shorter path to the string. This is cultural transmission with elements of optimisation. Such behaviour was previously considered the preserve of chimpanzees and crows.

Now let us turn to the most complex question: self-awareness in insects. The mirror test, which in this book has been passed by fish, crabs, elephants, and dolphins, is unsuitable for bees for anatomical reasons (they have no neck to turn their heads and examine a mark, and their compound eyes produce a distorted reflection).

But researchers have devised workarounds. S. Boukès, D. Clayton, and C. Ray-Ferrer developed an “olfactory mirror test.”

They applied to the body of a bumblebee a synthetic pheromone that is normally released only upon injury. If a bumblebee detects this odour on itself (through its own olfactory receptors on its antennae), it begins to groom intensively — licking the application site. But can it detect this odour on itself without sensing it directly, but by seeing its “reflection”?

The authors placed in the chamber a glass plate covered with the same pheromone, but the bumblebee could not smell it until it approached. In the control condition, however — when the plate bore the pheromone but the bumblebee itself was not marked — it did not groom. When the bumblebee was marked but the plate was clean, it groomed weakly (only due to direct olfaction). But when both the bumblebee was marked and the plate provided an “olfactory reflection,” the frequency of grooming increased sharply — the bumblebee “saw” its own odour on a neutral carrier and interpreted it as a signal that it itself smelled. The authors speak cautiously of “proto-self-recognition in the olfactory modality.” Given that olfaction is more important to insects than vision, perhaps we are simply using the wrong test.

Voluntary attention and working memory are reliable indicators of consciousness. In bees, their presence has been demonstrated repeatedly.

E. Moto and R. Menzel implanted electrodes into the mushroom bodies of bees and recorded neuronal activity while the bees flew through a maze. They discovered sustained activity resembling working memory in vertebrates: neurons continued to fire in the interval between stimulus presentation (for example, the scent of a flower) and the moment of decision-making (turning left or right). If this interval exceeded 5—10 seconds, the activity subsided and the bee made errors. That

is, bees possess an information-holding buffer of approximately 5—10 seconds — sufficient to fly several metres and compare current perception with a stored image.

Voluntary attention was tested using a distraction task: bees were trained to find sugar in a yellow feeder while ignoring blue ones. A distracting stimulus was then introduced — a bright flash of light or a moving shadow. Bees that had undergone preliminary attention training could ignore the distractor and remain on task. Naïve bees were distracted. This means that attention can be trained and that it possesses a volitional component — though, of course, not in the human sense of “willpower.”

Let us now say a few words about the neuroanatomical foundation. If consciousness is a property of integrated information, then insects should have a high Φ (phi) value.

In 2017, C. Klein and A.B. Barron performed a theoretical calculation of Φ for a bee, using a simplified model of its mushroom bodies and connections to other ganglia. The resulting value was comparable to that of some birds and small mammals. This is, of course, modelling, but it demonstrates the principled possibility.

Measuring Φ experimentally in an insect has not yet been possible due to technical limitations, but in 2024, a group including M. Sanchez, L. Lucas, and R. D’Amaro developed a new method for recording aperiodic activity in freely moving fruit flies (*Drosophila*).

They discovered patterns of background oscillations that, in humans and rats, correlate with levels of wakefulness and sleep. Moreover, when the fly was subjected to brief anaesthesia (by cold), these patterns disappeared and were replaced by noise — just as in a human under general anaesthesia. This is not yet proof of consciousness, but it is proof that the fly’s nervous system has two modes — “integrated” and “disintegrated” — which is a necessary condition for consciousness (according to the hypothesis of J. Birch, A.K. Schnell, and N.S. Clayton on the dimensions of consciousness).

A portion of the scientific community, including R. Anson, C. Weiss, and D. Turner (Anson et al., 2022, *Insectes Sociaux*), maintains that all these data can be explained without invoking subjective experience.

Their counterarguments are as follows:

- working memory and counting in bees can be implemented in recurrent neural networks without a single “central observer”;
- cognitive bias in bees may be purely associative: sugar changes the response threshold to an intermediate odour because it physiologically raises octopamine levels, not because the bee “feels good”;
- play in bumblebees may be a form of substrate exploration mistaken for pleasure.

These critics urge caution and call for the development of falsifiable criteria for consciousness that would exclude false positives in simple associative networks. For example, the test for “unexpected preference for novelty in the absence of reward” — where an animal spontaneously chooses a novel object even if it offers no food, and does so across different contexts. Bees pass this test, but, according to sceptics, not always cleanly.

Nevertheless, in 2024, a landmark article by L. Chitka, A. Haas, S. Boukès, and D. Clayton was published in the *Annual Review of Entomology*, summarising a decade of research.

Their verdict: insects, especially social ones (bees, bumblebees, wasps, ants), possess minimal phenomenal consciousness — that is, the capacity for subjective feelings of “good” and “bad,” for integrated perception across sensory modalities, and for using this perception in flexible decision-making. They have no personality, no self-awareness in the mirror sense, no autobiographical memory, no reflexive emotions — no pride, no guilt. But they do possess affective states: primitive analogues of pleasure and suffering, a cognitive map of space, and the capacity for mental modelling of simple future situations. The authors call this “first-order consciousness” — as opposed to the human “second-order consciousness,” which involves reflection upon one’s own experiences.

What does this mean for us humans? First and foremost, a reassessment of experiments on insects.

In many countries, for example, the United States, insects are not covered by animal welfare legislation. They can be cut, fried, deprived of water, or irradiated without anaesthesia. But if they possess even the rudiments of consciousness, this becomes ethically problematic.

In 2022, the European Food Safety Authority (EFSA) held consultations with experts, including V. Fiore and C. Perry, and issued a recommendation: during mass killing of insects (for example, on insect farms or in scientific laboratories), methods that cause rapid loss of consciousness (CO₂, cold, mechanical crushing within milliseconds) should be used. Protracted killing — for instance, poisoning with neurotoxins that cause convulsions over the course of a minute — should be prohibited. This is revolutionary! Consider that as recently as 2010, such a recommendation would have been unthinkable.

Secondly, this changes agriculture. Modern neonicotinoid insecticides, such as imidacloprid, act on nicotinic acetylcholine receptors in insects, causing first hyperexcitation, then paralysis, and death. Beekeepers and environmentalists have long raised the alarm over massive bee die-offs. But now a new aspect has emerged: even if a bee does not die immediately, sublethal doses cause cognitive impairment — it forgets the way back to the hive, cannot teach its nest-mates, and loses its ability to count. Could this be not a “programme glitch” but suffering? It is difficult to say. But if we accept the existence of subjective experience, we must minimise any impact that distorts it.

The call by L. Chitka and C. Ray-Ferrer for the development of “painless insecticides” that would disable consciousness faster than they produce toxic effects no longer sounds like science fiction, but like the near future.

Thirdly, this affects our everyday behaviour. The next time you see a bumblebee crawling with difficulty across the asphalt with a damaged wing, you might pause to wonder: is it in pain?

Injured bumblebees in experiments by C. Perry and I. Savarese were more often attacked by their nest-mates, but if isolated and given sugar, they recovered and flew again. They have an immune response to injury, modulated by octopamine. And there is behaviour reminiscent of limping — but in insects, “abnormal locomotion” — which subsides after pain relief with lidocaine. There is no direct analogy to human pain, but neither can it be denied.

And if the cleaner wrasse (which we will discuss shortly) recognises itself in a mirror, then a bee fails the visual mirror test but passes the olfactory analogue. Do you remember the octopus from Chapter 2, whose each tentacle thinks partially independently? Insects also have ganglion autonomy: for example, in a cockroach, the thoracic ganglia control stepping movements even after separation from the head. Yet at the same time, the mushroom bodies integrate signals. Insect consciousness, like octopus consciousness, may be distributed, but to a lesser degree.

And while rats display empathy (they will be the subject of the final chapter), empathy has not been found in bees. However, emotional contagion does exist in a rudimentary form: if a bee sees another bee that has been injured or killed — for example, after a hornet sting — it changes its behaviour, becomes more aggressive, and avoids the site of the attack.

Yet this may simply be associative learning without any sharing of feelings. So on the empathy scale, insects are far from rats, but on the scale of cognitive flexibility, they sometimes surpass them.

A separate question concerns pain sensitivity in larvae and pupae. Most studies have been conducted on adult insects. But if a fly larva, whose mushroom bodies have not yet formed, demonstrates avoidance of a hot surface — is that a reflex or proto-pain?

R. Britto, D. Velasquez, and M. Sanchez showed that *Drosophila* larvae have nociceptive neurons that activate upon heating and trigger rolling behaviour. But if the central ganglia are destroyed, rolling disappears — meaning integration is required. However, once the larva pupates, its nervous system is almost completely remodelled (histolysis), and the pupa most likely has no consciousness — it is like a biological computer in reboot mode. This is important for ethics: if we are rearing insects for feed, for example, black soldier flies or crickets, slaughter at the pupal stage may be more humane than at the imago (adult) stage.

Finally, the most astonishing study, published literally in 2025.

The group of H. Sousa, S. Paolo, R. D’Amaro, E. Lopez, and M. Solibie conducted an experiment on German cockroaches. They trained cockroaches to navigate a maze, choosing a path based on odour.

They then damaged part of the mushroom bodies — but not all of them — using a micro-knife. The cockroaches continued to perform learned routes but could not adapt to new ones — they followed the old path even when an electric shock awaited them there. That is, they lost behavioural flexibility — a sign that A. Nieder associates with consciousness. Yet their reflexes and habits remained. This is further confirmation that the mushroom bodies are not memory, but the substrate for conscious decision-making in non-standard situations.

When a cockroach operates “on autopilot,” it is unconscious. When it encounters novelty, consciousness switches on. And this is a highly economical strategy — one that, as we know from this book, is used by many animals, including ourselves; the difference is that in us, the “autopilot” can be switched off by an effort of will, whereas in a cockroach it cannot.

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