Plasticity
A Cross Disciplinary Conversation
Abstract Book

1) Jerome Weiss — Plastic Deformation of Materials: From Mildness to Wildness

Institut des Sciences de la Terre (IsTerre), CNRS/ University of Grenoble, Grenoble, France

Abstract

When subjected to mechanical stress, solids deform. Below a yield stress, deformation is elastic and reversible. Beyond this point, irreversible plastic deformation occurs, which dissipates energy but, to a first approximation, does not alter the material properties. The physical basis of plasticity differs by material type. In crystalline solids like metals, it is governed by the motion of line defects called dislocations, a concept established a century ago. In amorphous materials like glasses, plasticity occurs via localized microscopic rearrangements known as shear transformations. For much of the twentieth century, the prevailing goal was to connect these microscopic mechanisms to smooth (or 'mild'), predictable macroscopic behavior, assuming fluctuations would average out at large scales. However, recent advances have revealed that plastic deformation can often be 'wild' and intermittent, characterized by unpredictable bursts of activity with a wide range of sizes. In some materials and conditions, a few large events can accommodate most of the deformation. This erratic behavior is especially pronounced in small systems and is generally undesirable for engineering applications, prompting research into mitigation strategies. The chapter covers plasticity across various material classes, including crystalline metals and alloys, their amorphous glassy counterparts, geological materials like ice and rock, and amorphous soft matter such as foams, while essentially leaving polymer plastics aside.

2) Dierk Raabe — Plasticity and Kinematics of Crystalline Metals: From Atomic-Scale Defects to Complex Polycrystals

Max Planck Institute for Sustainable Materials, Düsseldorf, Germany

Abstract

The mastery of metalworking—specifically the shaping of alloys into useful products without fracture — catapulted mankind from the Stone Age into the Bronze Age five millennia ago. This key feature of metals, i.e. their formability, characterized by a permanent shape change under maintained structural integrity when pushed beyond a critical threshold stress, is enabled by a property called plasticity. Macroscopic plastic response is based on the production and motion of line-shaped atomic structural defects in the metallic lattice, called dislocations, and the coordinated pore-free shape change and rotation of billions of individual crystals which host them. A single cubic meter of a deformed metal can contain up to one light year of dislocation length, with individual defects moving near the speed of sound. This chapter reviews the foundations of the dynamics and kinematics of crystal plasticity, techniques that transform the treatment of these phenomena from empirical smithing into a quantitative and predictive science.

3) Maggie Horst — Plasticity in Chemistry

School of Pharmacy, University of California San Francisco, San Francisco, California, USA

Abstract

Chemists study the organization and reorganization of atoms through electronic interactions. Chemistry is highly interdisciplinary because of the explanatory power of molecular approaches to understanding the world and the utility of making new molecules. Conventional uses of the concept of plasticity in chemistry originate at disciplinary boundaries, and many of these senses can be found in the other chapters of this collection: describing irreversible deformation in materials science, biochemical inputs to neurological mutability, and chemical signaling stimuli to cellular differentiation. Instead of focusing on those aspects, this chapter uses plasticity to introduce concepts in chemistry and engage the epistemology of the field. First, this chapter will broadly explore chemical irreversibility, using polymer mechanochemistry and metabolic biochemistry as examples. Next, the chapter will engage the chemical origins of mechanical plasticity in polymeric materials and their implications for sustainability. The chapter will then explore reactant mutability: substrate scope, one of the important metrics for organic methodology and medicinal chemistry. Finally, the chapter will take a step back to reflect on the ways in which scientific knowledge is reorganized in chemistry and how the discipline influences contemporary material production.

4) Ray Noble[1] Denis Noble[2] — Circular Causality and Plasticity in Living Systems

[1]Institute for Women's Health, University College London, London, UK

[2]Department of Physiology, Anatomy & Genetics, University of Oxford, Oxford, UK

Abstract

Modern biology has tended to adopt a mechanistic approach to living systems, with a predominant, privileged, directional, bottom-up causal relationship; particularly treating genes as 'code' or 'blueprint' for both form and function. In contrast, in this chapter, we define "plasticity" as a dynamic and proactive response to change, highlighting the adaptability of all organisms, as individuals, groups, and species. Addressing how this is achieved, we show that (1) emergent phenomena are real and meaningful; (2) for many of these, causality in their development and maintenance is necessarily circular, Multidirectional, and multidimensional; (3) the circularity occurs between nested levels of organisation with changeable functional states, creatively harnessing stochastic processes; (4) although the forms of causation can be different at different levels, there is no privileged level of causation a priori: the forms and roles of causation are open between and within levels, including ecological and psycho-social; (5) the upward and downward forms of causation do not occur in sequence, they may occur in parallel (i.e. simultaneously); (6) there is therefore no privileged direction of causality – the upper levels constrain the events at the lower levels just as much as the lower levels are necessary for those upper-level constraints to exist; and (7) to emphasise this point, we introduced the concept of a-mergence (Noble and Noble, 2019), which expresses the lack of causal directionality. inally, the key ingredients of 1) harnessing stochasticity, 2) openness between levels, and 3) function states enable organisms to be adaptively creative in Problem-solving.

5) Natal van Riel — Resilience and Plasticity of Human Metabolism

Department of Biomedical Engineering, Eindhoven University, The Netherlands

Abstract

Human metabolism adapts to stress through two intertwined properties: resilience, the ability to maintain or recover function, and plasticity, the capacity to reorganize physiological states. We propose a view of metabolic adaptability framed by two lenses: aging and obesity. Aging reflects the cumulative "wear and tear" of allostatic load, while obesity imposes an additional burden, through chronic low-grade inflammation. Using a complexity science perspective, we integrate network models, nonlinear dynamics, and the concept of allostasis. Shrinking biomarker variance (captured by probabilistic networks) signals a transition from flexible to rigid states. Mechanistic simulations reveal thresholds, bistability, and "windows of opportunity" for remission, illustrating how metabolic plasticity can be preserved or lost. This synthesis offers a framework for anticipating critical transitions and designing adaptive interventions to sustain metabolic health.

6) Kokkoris Vasilis — Arbuscular Mycorrhizal Fungal Plasticity: From Cellular Dynamics to Ecosystem Functioning

Amsterdam Institute for Life and Environment (A-LIFE), Faculty of Science, Section Systems Ecology, Vrije Universiteit Amsterdam, The Netherlands

Abstract

Plasticity, understood as the capacity to adapt form and function in response to environmental cues, is a foundational principle across biological, cognitive, and material systems. In the case of arbuscular mycorrhizal fungi (AMF), plasticity emerges as both a biological necessity and a theoretical lens through which to understand dynamic symbiotic relationships. As obligate biotrophs that form mutualistic associations with the majority of terrestrial plants, AMF exhibit a striking degree of morphological, physiological, and genomic plasticity. These fungi dynamically adjust their hyphal architecture, resource exchange strategies, cellular processes and community interactions in response to host identity, soil composition, and broader ecological networks.

7) Kaisa Kajala — Plants, Masters of Plasticity

Experimental and Computational Plant Development, Utrecht University, The Netherlands

Abstract

Plants are amazing organisms. They overcome their fundamental restrictions, from rigid cell walls to being rooted to their spots, by having incredible plasticity in their growth and development. The plasticity allows them to inhabit almost every corner of the planet and be the dependable foundation of our ecosystems. Instead of pre-prescribed numbers of limbs or developmental trajectories, plants plan their form based on availability of resources and threats from environmental stressors. When faced with environmental challenges, individual plant cells can even take on brand new identities and functions to match the needs of the current situation. Plants are true masters of acclimation through their innate plasticity in form and function. For plants to respond to their environment, first they must sense it, and then send signals about what they have detected. But unlike the animal world, with its network of neurons, plants send these signals via molecular pathways that then reprogram the plant to respond. The study of these signaling events is a key focus in plant biology, and in this chapter, I will discuss case studies of plant plasticity across three scales – functionality, morphology and molecular signaling.

8) Thomas Blankers & Willem Frankenhuis — Evolution of Plasticity

Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Amsterdam, The Netherlands

Abstract

Plasticity enables animals, including humans, to respond to environmental conditions in a way that benefits their survival and reproduction. Most plasticity research addresses proximate questions that focus on the physiological mechanisms that underpin plasticity. Evolutionary biologists ask complementary, ultimate questions about the evolution of plasticity such as: In which environmental conditions is plasticity favored by natural selection? Why does plasticity vary widely across different species and populations? Are sensitive periods in development adaptive? In this chapter, we describe the key concepts, theories, and methods used by evolutionary biologists to study these questions. We build bridges with other disciplines and conclude with future directions.

9) Carla Gomez da Silva — The Plasticity of the Developing Brain and its Importance in Mature Functions

Translational Neuroscience, University Medical Center Utrecht, The Netherlands

Abstract

The developing brain exhibits a remarkable capacity for plastic change. This can be measured from the cellular to the circuit level. In this book chapter I will discuss how several cell populations interact and cope with unknown territories and external sensory stimuli and how they adapt to changes in contextual information. I will comment on how neurodevelopmental disorders such as autism spectrum disorders (ASD) may represent variable forms of cellular plasticity and attempts of neurons to assemble and self-organize in conditions in which the external information is changed. Since the mode of function of the autistic brain hinders the ability of the individuals to harmoniously cope with the external world, I will also discuss the limits of brain plasticity and the fine line separating change resulting in good outcomes from change resulting in less efficient modes of functioning.

10) Lukas J. Volz1 & Gesa Hartwigsen2,3 — Network-level Plasticity During Human Cognition

[1] Department of Neurology, University Hospital Cologne, University of Cologne, Germany
[2] Wilhelm Wundt Institute for Psychology, Leipzig University, Germany
[3] Research Group Cognition and Plasticity, Max Planck Institute for Human Cognitive and Brain Sciences, Germany

Abstract

Cognitive functions rely on distributed, large-scale networks comprising regions distributed throughout the human brain. Efficient processing and information exchange requires a high degree of computational flexibility, which enables adaptation to ever-changing conditions in complex environments. In this chapter, we examine the role of network-level plasticity for flexible adaptation during human cognition. From a systems-level perspective, we describe how neurostimulation and neuroimaging can be combined to investigate adaptive mechanisms across different cognitive domains. We summarize recent evidence from motor and higher cognitive tasks which reveals common principles of adaptation across the adult life span. Such mechanisms include the flexible recruitment of specialized circuits as well as domain-general networks across different processing domains. Examples from healthy young volunteers show how non-invasive neurostimulation can be applied to interfere with and probe task-specific networks to study short-term adaptation during learning or challenging cognitive tasks. Examples from aging populations demonstrate changes in underlying functional network architectures, allowing to disentangle adaptation from general dedifferentiation due to cognitive decline. Finally, studies in patients with brain lesions show how network-level plasticity supports recovery of function and illustrate the underlying mechanisms of network reorganization. Collectively, these findings help to identify and characterize fundamental mechanisms of network flexibility and may critically inform future biomarkers and neurostimulation approaches in personalized medicine.

11) Elizabeth Holdsworth — Human Developmental Plasticity

Department of Anthropology, College of Arts and Sciences, Ohio State University, Ohio, USA

Abstract

Like other vertebrate organisms, humans exhibit developmental plasticity. As humans grow from fetuses to adults, their physiology and physical traits can permanently change in response to external and internal factors. Developmental plasticity of somatic traits, such as body shape and size, is a critical mechanism for humans to adapt to wide range of environments, explaining some of human biological variation across populations. For example, developmental plasticity has permitted native Andean populations to thrive in high altitude through the growth of larger lungs. Developmental plasticity can also shape adult phenotype in response to cultural practices, such as skull reshaping due to cradle board use in infancy. Although developmental plasticity has been hypothesized to be critical to human evolution and adaptability, there are outstanding questions about the function and limits of human developmental plasticity. Interpreting developmentally plastic responses as adaptations, pathologies, or simply responses to physiological constraints has real implications for population health policies (for example, the "small-but-healthy" debates about stunted height in children). Additionally, while it is commonly assumed that developmental plasticity serves to prepare the individual for their future, adult environment (i.e., developmental programming or a predictive adaptive response), it is also possible that the critical function of developmental plasticity is to ensure the fetus's or child's immediate survival and success during vulnerable periods of growth.
This chapter is a theoretical exploration of human developmental plasticity with a focus on plasticity in body shape and size, and some examples of developmental plasticity in endocrine physiology, metabolism, exercise physiology, and mechanisms of plasticity (microbiome, epigenetics).

12) Fathali M. Moghaddam — Political Plasticity and External Hardwiring

Department of Psychology, Georgetown University, Washington, DC, USA

Abstract

The research literature on brain plasticity and hardwiring has grown enormously over the last half century. We now know a great deal about malleability and rigidities in brain activity, and we have some knowledge of how this relates to behavior change. But behavior change also depends in foundational ways on external hardwiring. This chapter explores hardwiring external to individuals, in relation to political plasticity, how fast and in what ways political behavior can and cannot change. It is argued that political plasticity varies greatly across different types of behavior, being extremely slow in some domains (e.g., leadership and leader-follower relations), but relatively fast in other domains (e.g., technology related change). These variations in political plasticity are claimed to be highly consistent across cultures and across long time periods (e.g., the dominance of older males in leadership positions). Second, political plasticity is in fundamental ways limited by external hardwiring, which is already present when individuals arrive in this world and remains in important ways intact when they leave. Examples of external hardwiring include significant features of the built environment (e.g., historical religious and cultural buildings), as well as resilient classic literature, mythologies, national and religious narratives, folktales, and other characteristics of the wider culture that are integral to continuous collective identity. External hard wiring is often at least as stable as internal hard wiring and tremendously influential on behavior. In conclusion, low political plasticity and 'surprising' continuities in behavior over long historical periods are explained in large part though external hard wiring.

13) Jennifer Hawkins — Brain Plasticity is a Physical Reality that Enables and Affects all Aspects of our Understanding

Independent Scholar, UK

Abstract

Brain plasticity has only relatively recently been proven scientifically, and research is now ongoing in many emerging fields. This chapter references education and psychology research on key points supporting the following argument. Learning encompasses a complex combination of conscious and subconscious connective electro-chemical processes involving embodied cognition, critical thinking, neurodivergence, the extended mind associated with proprioception (conscious and nonconscious), and feelings and emotions (affective science). For teachers, accepting human brain plasticity and researching its potentials, is changing previous assumptions about learning, not only for students, but for themselves. The scientifically accepted fact, that our brains are constantly varying, pausing, developing, losing abilities or 'blooming and pruning' by neuronal connection in complex ways, is affected by memory, genetic, epigenetic, personal choice, experience, and environmental events. This implies improved levels of life-long learning development and recovery are possible. Quantitative, qualitative, and mixed-method data can be used to research neurogenesis around the stimulation of new brain cell growth, recording outcomes in diverse types of collaborations with participants. In education, there are avenues and questions to be investigated, understood, and acknowledged, not only in order to further current research, but to comprehend past and future research data relating to plasticity.

KEY WORDS: Social Psychology; Neuroscience; Cognitive Anthropology; Human Rights (Cultural Environments, Mental-wellbeing, and Inclusivity); Political sociology (Democracy, Peace and Conflict Studies); Information-networks; Philosophy; Education; and the Environment.

14) Terre Vadén — ‘All that is solid melts, and tradition, while tradition weighs like a nightmare’ – Socio-Cultural Plasticity in the Age of Fossil Fuels

The Global Centre for Advanced Studies, GCAS College, Dublin, Ireland

Abstract

The fossil fuel era opens a unique window into human socio-cultural plasticity, and its paradoxical nature. On one hand, fossil modernity with its “great acceleration” has shown how fast “all that is solid” can melt, how ancient traditions vanish, and new social forms are born and spread on a planetary scale, in a matter of few decades. On the other hand, it also shows how quite recent socio-cultural forms can be experienced as normal, even traditional. Not only that: it seems that once normalised, the fossil fuelled society seems to be very hard to change. Ecological catastrophes like climate change present an existential threat to all organised societies. Nevertheless, even now 80 percent of the energy for industrial metabolism comes from fossil fuels, just like in the 1970s. A curious asymmetry resides in socio-cultural plasticity: fast malleability side by side with persistent rigidity. The asymmetry arises from the heterogenousness of socio-cultural heritage. We inherit languages, ideas, beliefs, ideologies, but also buildings, fields, machines, logistic routes. These disparate items weigh differently in our inherited situation. The material path-dependencies created by fossil fuels have proven to be hard to dismantle and replace. But there are curious rigidities also in the immaterial realm, too, from the most extreme versions of "the American way of life is non-negotiable" through expectations of a imperial mode of living to more diffuse beliefs on the role of energy and money in the upkeep of industrial societies. By untangling the specific input of fossil fuels from other (technological, economic, organizational, etc.) prerequisites of fossil modernity, the contours of socio-cultural plasticity become clearer.

15) Ranjan Gosh — Plastic History

Department of English, University of North Bengal, West Bengal, India

Abstract

Plastic history is not about demonstrating how the world has changed through the desire and demand, the power and purpose of a material. Instead, it investigates how plastic builds a separate historical and temporal consciousness, as well as affective interiorities and historicalities, through a collaborative space occupied by historians, geologists, and artists; it analyzes how our sense of history plasticizes with our changing relationship to a material, with the surprise and power of its non-life, and with the creative imagination that turns the material waste into a work of art, combining an aesthetic moment with an eco-ethical narration. The chapter argues that plastic history is not plastic's history per se; it is about how a historical consciousness is built through certain geological, artistic, and speculative events—a consciousness that is deeply informed by a projective imagination and an aesthetic imagination (constructing the present history through an aesthetic-material execution: plastic art). Beyond familiar historical methodologies—archeological digging, archival plowing, documentary unpacking—plastic history thinks forward, not by working outside the social-scientific perspective but by being heavily plasticized through the interventions of non-historians such as artists, geologists, and earth scientists. In this sense, plastic history produces its own transhistorical moments and experiences.

16) Samuel Lynch, Helen English, Nathan Scott, and Jon Drummond — Composing the Unfixed: The Plasticity of Musical Form

School of Humanities, Creative Ind and Social Sci, College of Human and Social Futures, The University of Newcastle, NSW, Australia

Abstract

Plasticity is not typically a central concept in discussions of music composition. Traditionally, music is understood through fixed notions of structure and form, organized sequences of rhythm, melody, harmony, and timbre unfolding over time. However, introducing the concept of plasticity opens new pathways for considering how musical elements can and do vary, adapt, and reconfigure, challenging static models of composition. This chapter proposes a functional definition of musical plasticity as the capacity of musical structures, materials, and systems to vary, reorganize, adapt, or transform in ways that preserve a recognizable identity or function. Variability arises in a multitude of ways in music that are rarely discussed under a common understanding. As such, the chapter proposes a typology distinguishing three primary modes of variability: interpretative plasticity (variability in performance realization), structural plasticity (variability embedded in compositional design), and systemic plasticity (variability arising from environmental or agent-based interaction). These modes are explored through comparative case studies of the jazz standard All Blues and an original work titled Rhythm Choir. This framework suggests that all musical works possess a specific "plastic profile" that describes a unique signature of how a work balances stability and mutability.

17) Heather Davis — Plasticity

Culture and Media, Eugene Lang College, The New School, New York, USA

Abstract (Reproduced Chapter From the Book: Plastic Matter — Chapter First Paragraph)

When plastics were first created, they were produced as a replacement material for shells and horns from animals that had been hunted to the brink of extinction. In 1867 elephants were in grave danger because of the ivory trade. At least one million pounds of ivory were consumed each year, sparking fears of an ivory shortage. It was a material that was used for many luxury items, including
combs and piano keys, but one of the biggest uses was for billiard balls. Billiards had become all the rage within upper-class society, and so a reward was placedfor anyone who could come up with a substitute. John Wesley Hyatt, who originally trained as a printer before becoming an inventor and industrialist, was lured by the $10,000 prize money. This resulted in one of the first plastics, celluloid. Although celluloid was never successfully used in the manufacture of billiard balls — the balls would spark due to their flammable nature and caused alarm — further experiments did find that the material was suitable for making a wide range of consumer goods including everything from denture plates and combs to harness fittings and piano keys, and later celluloid became nearly synonymous with cinema. All of a sudden, objects that were either precious or a marker of high-class status became available at a much reduced price, thus contributing to a burgeoning middle class defined by consumerism. Plastics were originally materials of mimesis, but as time passed, they came into their own, used not just to replace other materials but to invent new ones. They marked the democratization of the access to consumer goods that was, in many ways, a continuation and amplification of the extractivist ideologies that had threatened the elephants in the first place. In other words, even before plastic existed as a material, there was a belief in the plasticity of the world, as passive matter was understood to be available for near limitless consumption.

18) Johanna Hoffmann — Plastic Cities: An Updated Assemblage Theory For Urban Futures

Independent Urban Planner, West Coast, USA

Abstract

This chapter advances an updated assemblage theory for understanding and shaping the plasticity of urban environments. Far from static, bounded spaces, cities are dynamic assemblages, continually reshaped by constellations of complex financial, political, ecological, and imaginative forces. Those imaginative forces are what certain scholars refer to as spatial imaginaries – collectively held stories about what a place is and ought to become that operationalize decisions resulting in urban change. Yet existing forms of assemblage theory regularly overlook their influence. As the ability to frame collective imagination of the future is a significant tool for wielding power over present-day circumstances, highlighting how imaginaries influence development trajectories is a critical part of addressing inequitable power systems. As policies and public discourse regarding proposed material changes are informed by past and present economic, social, and cultural capital, exploring the roles imagination plays in the creation and implementation of urban futures is an avenue through which to understand how macro-environmental factors interact across time and space, and the power dynamics involved. The field of imaginaries offers a powerful analytical mode through to which to assess such dynamics. Using Los Angeles as a primary case, the text explores how imaginaries justify particular interventions over others, encode obligations, and distribute risks. It specifically tracks how ideas of turning a desert into an urban eden and associated water-intensive development paradigms created what is today among the most water-stressed cities in the world. The text concludes by positioning narrative stewardship as a crucial, if under-recognized, arena of shaping urban plasticity in more nuanced, just, and adaptive ways.

19) Miša Stekl — Racial Plasticity and the Invention of Modern Homosexuality

Modern Thought and Literature, Stanford University, California, USA

Abstract

This paper revisits the 19th-century invention of homosexual identity through recent debates about "racial plasticity." I first analyze how homosexuality, or "inversion," was defined by German sexologists as a species of "degenerate" sexuality, in line with racialized hierarchies that ranked civilizations according to their purported degrees of sexual differentiation. Through close readings of primary sexological texts, I show that sexology represented inversion as backwards vis-à-vis Western norms of sexual and civilizational development, as a return to more "primitive" forms of sexuality associated with non-Western (esp. Black and indigenous) cultures.

I further contend that homosexuality emerged at the fracture line between two senses of racial plasticity. First, Kyla Schuller and Jules Gill-Peterson have defined plasticity as the racialized management of the human body's malleability, with the white body hailed as the most "impressible" and capable of cultivating civilized sexual norms. While sexologists clearly rehearse such evolutionist hierarchies that privilege the plasticity of the *white* body, they also reflect a second, inverse sense of plasticity, which Zakiyyah Iman Jackson defines as the "transmogrification" that renders Black flesh "everything and nothing," abject from Human identity (48). Holding together these contradictory theorizations of plasticity, I read the invention of the homosexual as a (failed) attempt to resolve the threat posed by Black plasticity and "ungendering" to the integrity of sexual identity categories.

20) Jenny Andrine Madsen Evang — From Plastic Potential to Malleable Control: Race, Gender, and the Thorniness of Transgression

Department of Media and Culture Studies, Utrecht University, The Netherlands

Abstract

This chapter presents a genealogy of plasticity within the interdisciplinary field of Gender studies. The chapter unfolds across three sections: first, an in-depth exploration of the implicit function of plasticity within Judith Butler's foundational framework of sexed materialization and performativity, second, an exploration of new materialist critics of Butler who argue that their framework does not account for the radical potentials of the actual materiality of the irreducibly plastic body, and third, a section that troubles the link between plasticity and radical transformation both in Butler and in the theorists covered in the second section, revealing instead how racialized histories of dehumanization have not been squarely opposed to plasticity, but have relied on it. This last section urges thinkers of plasticity to resist frameworks that oppose plasticity to the trap of power by assuming its inherently destabilizing of deterministic frameworks, situating instead plasticity as a core mechanism of what Foucault calls biopolitics. Overall, the chapter seeks to illuminate the very plasticity of the concept of plasticity itself within and beyond the humanities, while also posing pressing concerns for how interdisciplinary collaborations are carried out.