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Voices of chemical biology

Agreeing on a precise definition of chemical biology has been a persistent challenge for the field. We asked a diverse group of scientists to “define chemical biology” and present a selection of responses.

Chemical biology is an area of research in which chemical and biological concepts and tools interact synergistically in the pursuit of new discoveries or technologies.

Carolyn R Bertozzi

Stanford University, Palo Alto, California, USA

Chemical biology is the exploration of mechanisms governing living systems using tools, methods and analytical frameworks involving molecular structures. This includes the classic definition of chemical biology, which is the use of synthetic organic chemistry to create small-molecule probes of biological processes; it also encompasses a broader set of efforts in the growing chemical biology community, such as molecular pharmacology, single-molecule biophysics, synthetic biology, chemical proteomics and chemical systems biology. In short, I think of chemical biology as the use of chemical methods to understand biological processes.

Brent R Stockwell

Columbia University, New York, New York, USA

It is chemistry brought to life: the science of applying chemistry to understand and perturb biological processes.

Stefan Kubicek

CeMM Research Center for Molecular Medicine of the Austrian Academy of Sciences, Vienna, Austria

Chemical biology is both the application of chemical approaches and tools to biology and the application of biological molecules and systems to chemistry. Chemical biologists often invent new tools and methods, but they also pursue pure biological research in a way that is colored by the perspective of a chemist. A key strength of chemical biology is that it is not hampered by rigid definitions, and can therefore embrace new ideas and shift directions more freely than other fields.

Bryan C Dickinson

University of Chicago, Chicago, Illinois, USA

Chemical biology involves viewing the world around us, the living organisms and their environment, through the lens of a chemist, and taking advantage of the

unique ability of chemists to not only study but also create new forms of matter at the molecular level for societal benefit.

Christopher J Chang

University of California, Berkeley and HHMI, Berkeley, California, USA

Chemical biology is destined to answer questions in biology in the broadest sense by using chemistry, chemical techniques or novel chemical probes, but with the biology in the center of the work. Chemical biology differs from biochemistry because the latter is usually defined as a disassembled and reconstituted system of biomolecules whereas chemical biology might be targeting or attempting to understand chemistry in intact cells, tissues or whole animal systems.

Carsten Schultz

European Molecular Biology Laboratory, Heidelberg, Germany

Chemical biology is using biology to do new chemistry and using chemistry to probe biology.

Pamela A Silver

Harvard Medical School, Boston, Massachusetts, USA

Chemical biology is focused on the development of new molecules or approaches that are purposefully and intentionally designed to address specific gaps in biological knowledge. In other words, ‘tool making’ occurs hand in hand with ‘tool using’.

Jason E Gestwicki

University of California, San Francisco, San Francisco, California, USA

Chemical biology is a science in pursuit of biological and medical questions that are less amenable to being tackled with (or refractory to) classical methods such as those routinely used in cell biology, genetics and biochemistry. The unique properties of the chemical tools suggest that chemical biology not only is complementary to other sciences but also has a cutting-edge advantage in certain investigations of biology.

Gabriela Chiosis

Memorial Sloan Kettering Cancer Center, New York, New York, USA

Chemical biology, in the broadest sense, addresses the interface between chemistry and biology and sometimes physics.

It provides a way to explore biological phenomena based on physicochemical principles.

Amitabha Chattopadhyay

Centre for Cellular and Molecular Biology, Hyderabad, India

Chemical biology is the application of chemistry to investigate biological systems or to solve biological problems. Whereas traditional disciplines, such as organic chemistry and biochemistry, have a vertical focus, applying techniques to discipline-specific questions, chemical biology has a more horizontal focus, borrowing tools from organic chemistry, biochemistry, analytical chemistry, molecular biology, structural biology and/or cell biology to study biological questions at the molecular level.

Rebecca A Butcher

University of Florida, Gainesville, Florida, USA

Chemical biology is the discipline focused on understanding the fundamental mechanisms of various biological processes at the molecular level. This knowledge can be used to control and modulate these biological processes, especially disease-relevant biological pathways.

Seung Bum Park

Seoul National University, Seoul, Korea

To paraphrase Sydney Brenner, chemical biology is that field of science that is conducted by chemical biologists.

Brian K Shoichet

University of California, San Francisco, San Francisco, California, USA

Chemical biology is a broad area of research representing the interface between chemistry and biology. Chemical tools and concepts are used to understand and/or control biological processes at the molecular level. These tools can be synthetic, such as the generation of small or large synthetic probes and natural biomolecules, or they can be analytical, including diverse spectroscopic methods and informatics and computational approaches. Chemical biology can be used to investigate and

manipulate reactions and molecular interactions *in vitro*, but increasingly its tools are used to target biological processes inside living cells and organisms.

Sabine L Flitsch

The University of Manchester, Manchester, UK

Chemical biology is a discipline in which chemical tools, methodologies and principles are applied to biological systems.

Jin Zhang

Johns Hopkins University, Baltimore, Maryland, USA

As is the case with many rapidly developing fields, the definition of chemical biology has evolved. Although it was originally associated with the use of small molecules to probe biological pathways, it has been inspiring to see chemical biology expand to embrace concepts such as the use of biological principles to advance chemistry, the precise manipulation of macromolecules to study biology and inform novel therapeutics, and many others. For me, chemical biology is not simply a research field, but a philosophy about discovering, synthesizing and manipulating molecules to illuminate life and improve the human condition.

David R Liu

Harvard University, Cambridge, Massachusetts, USA

In my opinion, chemical biology is characterized by its methodologies. For example, in addition to molecular biological techniques, organic chemical techniques are often used for analyses of the functions of biomolecules in cells and in living organisms.

Yasuo Ohnishi

University of Tokyo, Tokyo, Japan

It is hard to define chemical biology because it is an inherently diverse discipline that brings together tools from disparate fields. I prefer an all-encompassing definition where a unifying feature is addressing biological problems with a chemical mindset.

Eranthie Weerapana

Boston College, Chestnut Hill, Massachusetts, USA

Chemical biology is the intimate codependence of chemistry and biology, where chemical processes are used to drive the understanding of biological phenomena.

Allison H Williams

Institut Pasteur, Paris, France

I define chemical biology as broadly as I can. I would think any research using chemical tools, approaches and knowledge

to probe, uncover and understand biological processes could be considered chemical biology. The key is learning new biology.

Chuan He

University of Chicago, Chicago, Illinois, USA

Chemical biology addresses the interface between physical chemistry and biochemistry. It uses the atomistic understanding of chemistry on molecules and in molecular interactions and applies it to defined and reduced biological systems. This knowledge is then used to describe biological systems on a higher scale.

Anna Moroni

University of Milan, Milan, Italy

Gerhard Thiel

Technical University of Darmstadt, Darmstadt, Germany

Chemical biology is solving biological problems with chemical tools, or developing the tools for elucidating or formulating unexploited biological questions.

Young-Tae Chang

National University of Singapore, Singapore

How would you define chemical biology?

Chemical biology is the development and application of novel chemistry to the study of biological phenomena and processes. By definition it includes both genuine chemical and biological components. It is not just another kind of biology.

Herbert Waldmann

Max Planck Institute of Molecular Physiology, Dortmund, Germany

I see chemical biology as the use of chemical tools to study biological processes in depth. I know many people would argue that it is no different from classical pharmacology. However, I feel the difference is that new design methods and technologies have enabled chemicals, which formerly could only provide phenomenological data in biologic systems, to be used to understand complex systems and pathways in biology. So I would argue that technology has largely shaped the transition of our thinking about chemical tools and probes from one of classical pharmacology to one of chemical biology.

Matthew Bogoy

Stanford University, Palo Alto, California, USA

For me, chemical biology is the science of how chemical substances influence or control biology. The ‘biology’ influenced by chemistry can be either an isolated biological molecule, for instance a nucleic acid, or a larger entity, such as a whole cell or an organism. The ‘chemical substances’ could be small or large molecules and may include both organic and inorganic components.

Lene B Oddershede

Niels Bohr Institute, Copenhagen, Denmark

In my mind, chemical biology is the application of small-molecule probes, which are complementary to the tools available from biologists, to interrogate biomolecular targets and their associated cellular pathways with a view to obtaining new biological insights. Its origins are in chemistry, but are ported over toward answering biological questions. The goal of chemical biology is one of interrogation and ‘illumination’, and not necessarily a therapeutic outcome.

Arthur Christopoulos

Monash University, Parkville, Australia

Chemical biology is the application of chemical and physical principles and experimental and theoretical approaches for dissecting the molecular detail of the biological reactions and interactions in living systems.

Barbara Imperiali

Massachusetts Institute of Technology, Cambridge, Massachusetts, USA

Chemical biology is a ‘multiphase’ discipline lodged between chemistry and biology. Its roots expand in both directions, but are dependent upon the goals of the scientist. This battle of wits with Nature is the driving force for the implementation of chemical approaches in biology.

Hermann Ehrlich

Technical University of Freiberg, Freiberg, Germany

Chemical biology is an interdisciplinary research field in which chemical tools and technologies are developed for investigating biological processes. Similarly, studying biological systems can facilitate evolving new chemical principles.

Xing Chen

Peking University, Beijing, China

When I was crafting a graduate chemical biology course at UCI a few years ago, I asked my colleagues this same question. One memorable response was: “Let me know when you figure it out!”

Jennifer A Prescher

University of California, Irvine, California, USA