Unity in diversity biology definition

To continue to enjoy our site, we ask you to confirm your identity as a person. Thank you so much for your cooperation. Biology is extremely diverse in its methodologies, concepts, theories and goals. It also develops rapidly and reveals deeper complexities at almost every level of organic organization. For these and other reasons, biology is becoming more specialized and fragmented. Is there a cure for this condition of things? Are there historical or philosophical resources to help? Can biologists communicate more effectively and create a new, truly comprehensive modern synthesis? To answer these questions, we discuss the need for a specialist and generalist in biological sciences and argue that these two roles are not mutually exclusive. In fact, although relatively rare, the specialist is an example of the achievements of Charles Darwin and Louis Pasteur. We also discuss cross-science concepts identified by the National Academy of Sciences Board of Education, especially in the context of teaching integrated and specialized biology. We live in biology. Biological sciences are increasingly at the centre of constant environmental and social pressures, as well as various other factors, including the priorities of funding agencies. Important discoveries are made almost daily at every level of biological organization, from intracellular processes to the work of entire ecosystems. Discoveries are also made that reveal greater complexity at each level. The number of scientific journals is increasing at a remarkable rate (Figure 1a), as well as the number of journals dedicated to biology (Figure 1b). For example, the number of scientific articles published only in 2006 was a staggering 1,350,000 (Björk et al. 2008). The science of growth is so fast that some cited pointers are unable to adhere to it (Larsen and von Ins 2010). As a result of this growth and past trends, some see biological sciences as continuing to become more specialized, and specializations become increasingly conceptually isolated, as evidenced by the following two quotations, separated by 44 years: One may be glad to see the incredible growth rate of the repository of human knowledge.... But the magnitude of this store has overcapacity of even the most powerful human intellects to assimilate all knowledge. Gone is the time when a scientist... can be a person who is widely familiar with the modern state of science in general. (Dobjanski 1964, p. viii) The main achievements in biological knowledge are achieved through the interaction of theoretical insights, observations and key experimental results and through improvements in technologies that make possible new observations, experiments and insights. The fragmentation of biology in many subdisciplinaries means both that may differ dramatically from one area to another and that the development of theoretical insights that cross subdisciplinary can be difficult. (SCC, 2008, p. 7) Opens in a new sectionDownload slide(a) The number of scientific journals (globally) and (b) net growth in the number of biological journals in the twentieth century. Panel data (a) was obtained from Mabe and Amin (2001); those for panel (b) are obtained from ulrichsveb global serials directory, using advanced search for serial type: journal; type of content: academic/scientist; subject: biological sciences and agriculture OR medicine and health; format: print OR online. Surely our textbooks expand in size and often become obsolete in short order, as more and more specialized magazines appear on the shelves of our virtual and real libraries. Some colleagues find it extremely difficult to know what to teach, given the time constraints in our flight rooms and laboratories. We readily recognise that growth in the body of scientific knowledge does not necessarily mean growth in the fragmentation of this knowledge body. However, evidence of increasing fragmentation in biology is abundant. Consider, for example, the journal Nature. This journal was founded in 1869 to cover all science. Today, however, there are 26 nature spin-offs dedicated only to biology, ranging from nature chemical biology and nature genetics to nature structure and molecular biology and nature review microbiology, in addition to biology-oriented objects in nature photonics, natural physics, and natural materials (www.nature.com/siteindex/index.html). Similar evidence of fragmentation in biology can be gathered by reviewing journals as diverse as the American Journal of Botany and the Proceedings of the National Academy of Sciences, whose problems were not subject to biological appearance but whose current problems abound with them. This zeitgeist in the age of biology raises a number of important theoretical and practical questions. First, are biological sciences really in danger of becoming too fragmented? Secondly, if yes, can we identify conceptual or theoretical common things that will reunite them? And third, how do we make sure that the current generation of biology students is sufficiently prepared to become the next generation of biologists, while respecting the need for a plant biologist, molecular biologist and microbiologist? In the following sections, we address these issues in the context of two statements that are undoubtedly idealistic but still true. First, in theory (though not in practice), there is no intellectual separation between natural, physical or sociological sciences. Practitioners in any scientific field, consciously or unconsciously, are based on the methods, concepts and theories of each of the other sciences in one way or another, or and research in each field informs and gives perspective to all other areas, as evidenced by the contribution of physiologist Adolf Fick (who established the laws of passive diffusion by studying the transmembranous dissolution in the kidneys), botanist Robert Brown (who identified accidentally molecular movement by examining pollen in a liquid medium), physicist Gottsilf Hagen and physician Jean Pauley (who mathematically characterized the flow of fluids into thin tubes by examining blood flow) and Renee-Hui (who became the father of crystallography due to the release of a friend sample of limestone spar) for mathematics, physics, chemistry, biology, and many of the social sciences. The pursuit of science is therefore an interconnected enterprise, because advances in one science may ultimately advance all other sciences. In fact, the philosophy of science and the history of science show us that chemistry, physics, mathematics, sociology, and so on interface on many levels in each of the biological sciences. However, we also realize that each of the different biological sciences is becoming more specialized and that it is becoming increasingly difficult to fully integrate the development found in different biological sciences. The pressure to provide external funding and internal decisions on possession and promotion also tend to favour the specialist and often choose against the generalist whom some consider a dilettante (Wayne and Staves 2008). Secondly, we believe that no level of biological organization can be fully understood without understanding how all other levels of biological organization affect it and how it affects them. Each organism is an integrated phenotype, and each organism affects and is influenced by its environment. In fact, it is helpful of any science to recognize the relationship of the parts with the whole. For this reason, we believe that every biologist should be able to effectively teach an introductory biology course, as well as a course in his or her specialty. However, from our experience, this idealist of who should teach (and how biology should be learned) is not the norm. Many students are trained to be technically adroit but conceptually narrow-minded, and many new faculty are hired for their research expertise with little or no consideration of their teaching abilities. As a result, many biological subjects drop out of our curricula; former integrated departments are divided into separate units intended exclusively for organisms or molecular biology; and introductory biologies are either team-taught or abandoned entirely for the benefit of area-specific courses. Each of the biological sciences needs the specialist and the generalist. Both are necessary to displace scientific paradigms or to create new ones (Kuhn 1962). For this reason, we believe that graduate students need to learn the basic biological how to actively integrate them into each other, in addition to studying the details of their chosen field of study. In this way, each student can make an informed decision about the type of scientist they want to become (in light of the effects this decision will have on their scientific calling). We need to cultivate students who can simultaneously see the forest and the individual tree (or the coral reef and polyp), if for no other reason, except that these individuals are just as likely to be the next great communicators of science and the discoverers of new scientific highers. In the rest of this article, we present our reasons for making these claims; illustrate them by drawing on the achievements of Charles Darwin and Louis Pasteur, among other scholars; and to argue that students should learn not only basic biological concepts, but also how to interpret these concepts to each other and those used by other disciplines. The unity of science is a conceptual framework that has at least three important attributes: It is a body of knowledge that is firmly self-critical, constantly accumulated and increasingly explainable. Scientists study natural causation by accumulating empirical observations, constantly interpreting the meaning of these observations, and constantly subjecting interpretations to rigorous empirical tests. The pursuit of science begins with initially scattered observations that lead to preliminary interpretations. Over time and with prolonged observations and trials, these interpretations become more focused and precise in nature. Some interpretations will be dismissed as false, while others will eventually achieve the importance of scientific theory, which will nevertheless always be subject to experiential scrutiny. In fact, one of the attributes of a good theory is its resistance to increasingly rigorous tests. Biological sciences have all these qualities and are therefore not unique among sciences. They also share another trait with other sciences: their goal is to better understand nature in general and to understand our species in particular. All this has been said before and with greater eloquence: Science, as it is right and appropriate, endless pains on this experience, which in their absence would move away from misunderstandings or misunderstandings. They mark, make, and prophesy. They compare prophesy to the event, and they fully supply—so they are their intentions for reality—every possible and draining from the present dream. (Santayana 1998, p. 393) It seems clear and obvious, but it must be said: Isolated knowledge obtained by a group of specialists in a narrow field in itself has no value, but only in its synthesis with all knowledge and only insofar as it really contributes to this synthesis to meet the demand Who are we? (Schrödinger 1951, p. 5) However, between sciences do not guarantee cohesion between them or even within each of them. Some reasons for disunity in biology are less obvious than others. For example, consider terminology. The basal body of a cell biologist is called the kinesosome by the protozoologist, who calls the sloppy prop of the cell biologist of flagellum, which is a very different structure from the flagella studied by the bacteriologist. Similarly, what is known to the physiologist as syphonoclyte tissue is called symplast by the ryologist, who is known to the zoologist as singytium. Language is not the only obstacle to communication between biological sciences. Increasingly monoculous scientific journals, specialized conferences and symposiums, focused and rigorous funding priorities, departmental policy and institutional policy are among the other sociological influences and pressures that have driven wedges among different biological sciences and which have nurtured increased specialization at the expense of seeing biology as a single whole. In addition, a pecking order exists among biological sciences, where some consider certain areas of research as trivial or not necessary, a perspective that is often cultivated institutionally based on the amount of donations or enrollment in class. The cost of publication contributes to this state of play, as publication depends on funding and funding depends on publication. One consequence of this vicious circle is the disappearance of less popular lines of research. To paraphrase Chargaff (1976), what we consider chic science is conditioned by funding. The generalist specialist The history of science shows us that there is no question in any science that is too small for experiential persecution, but that the answer to each question takes on significance when understood and integrated into a broader interdisciplinary context. A reasonable scientist does not wait to see the greater consequences even of a small answer, because someone else will surely see them (and listen to it). The specialist should see any discovery in its broader context, just as the generalist must appreciate the importance of answering the most specialized questions. We recognize that this specialist – generalized attitudes is neither easy nor widespread. However, the effort is worth it. Many great discoveries began with seemingly small questions, and answers to small questions often lead to overarching scientific theories. Why is my wine soaked? What does this fungus do with these bacteria in my petri wee? Why are there scallops in the rocks at the top of this mountain? Why are some pea yellows and others green? These and many other seemingly banal questions about the world around us have led to some of the greatest scientific discoveries and some of the deepest and deepest scientific theories. One of the most well-known examples of how the response to you can adjust to a grand theory can be seen in Charles Darwin's detailed study of barracies (Cirripedia), which lasted 8 long years (1846 –1854; see Love 2002, Stott 2003). Darwin was interested in invertebrate zoology dating back to his time in Edinburgh, where he met Robert Grant in 1826. However, Darwin's highly focused interest in barracules can be traced back to two discoveries in 1835, during beagle's famous journey - the emergence of small, insignia, nascent parasitic boils in the gastrons and the discovery of the development of stages in their eggs that are similar to those of crustaceans. Before the publication of John V. Thompson's findings in 1830, most naturalists classified barules as mollusks. However, Darwin's observations, which are consistent with Thompson's, suggest a completely different classification. In 1846, Darwin engaged in a detailed reassessment of the undescripted boils collected during his journey, a particularly strange specimen collected in South America (originally called Arthrobalanus minutus, but later renamed Cryptophialus minutus), which has an articulated shell reminiscent of crustaceans. In light of the bitter state of how these creatures were classified until 1846, Darwin gradually accepted the views of von Bier, Milne-Edwards and others that classification was best based on embryological characteristics and a detailed understanding of homology. As a result of its fascination with barracules and huge variations in individual species, Darwin is increasingly convinced that species can and have changed over time and become new species. His observations of rudimentary parasitic male animals in the genus Ibla and complementary male animals on hermaphrodites in Ibla and scalpelum contribute especially to its acceptance of the transformational perspective. The first volume of Darwin's first volume (1851) research earned him the Royal Medal of the Royal Society of London in 1853 and cemented his reputation as a world-class scientist. More importantly, its intense focus on what some today might consider a very narrow specialty helped to develop and crystallize what may be the most unifying theory in biological sciences. Another example of the specialist is Louis Pasteur, who began his career as a chemist (Duclaux 1920, Geison 1995, Debré 1998). Pasteur knew from previous work that solutions made from the crystals of each tartare salt can rotate polarized light to the right, while solutions made from the crystals of sodium ammonium paratartrate synthesized in the laboratory cannot. Pasteur's uniformity helped him see that the tartare crystals were tilted asymmetrically on the right side, while the crystals of sodium ammonium paratartrate tilted the veneers on the right or left side. It separated the two types of paratarthral crystals, dissolved each group and found that with aspects on the right side, polarized light is rotated to the right, and those with a polarized light on the left. It also found that a solution made from a mixture of two types of crystals does not affect polarized light. Pasteur concluded that the inability of paratartrate to rotate polarized light is due to the neutralizing or compensating effect of the two mirror images. He also suggested that only living organisms can produce chemicals that are optically active. He tested this idea by feeding the fungus (Penicillium glaucum) paratartrate and found that, as the fungus grows, the ability of the food environment to rotate polarized light on the left increases. Pasteur serendipitous developed the biotechnology needed to isolate a specific stereoisomer. While studying fermentation as a chemist, Pasteur realized that decay, like fermentation, is caused by microbes and that life takes part in the process of death. Microbes facilitate the cycle of life by making available to living nutrients bound in dead organisms, including sulfur compounds that contribute to the smell of decay. Since the beginning of his work with winemakers, Pasteur has realized its potential medical benefits and that the germ theory of diseases applied to both the human body and those of grapes. Pasteur then correlates the presence of an unwanted microbe, Bacillus anthracis, with anthrax and streptococci pyogenes with septicaemia and puerperal (childbed) fever. While Robert Koch, the country's physician who worked in his home laboratory and won the Nobel Prize in Physiology or Medicine for his work in 1905, expanded Pasteur's germ theory to other diseases, such as tuberculosis and cholera, Pasteur continued to develop vaccines, including those for rabies, anthrax and cholera, that plagued both humans and animals. Pasteur, along with Ignaz Zemelweiss, Joseph Lister and Robert Koch, also saw the importance of simple measures and urged doctors to wash their hands between performing autopsies and delivering babies. Not limited by any artificial boundaries, Pasteur's eye can see the future of medicine, not in a crystal ball, but in crystal tartrate. As a third example of how a highly focused study can provide fundamental insights into biology in general, consider the work of Moser and colleagues (1992). In this study, the transfer rate of electrons defined in a number of biological and synthetic systems was compared with the standard electron transfer rates predicted by the theories of Marcus (1956) and Jortner (1976). The conceptual basis of this study is based on theoretical projections that electronic transfer depends on three main properties of the electronic transfer system: the distance between the electronic donor and the host (d), the difference in free energy associated with the electronic transfer process (ΔG) and the energy associated with the of the environment in which transfer (λ). Marcus (1956) predicted that for each value of d, the maximum electron transfer rate occurs when $\Delta G = \lambda$ — that is, when the free energy released by electronic transfer exactly coincides with the change in the free energy caused by electronic transfer. Early support for Marcus's theory comes from a 1989 study of electrical speeds in isolated photosynthetic centers, in which local electronceptors are replaced by structurally related compounds to change $\Delta G°$ of reaction until λ is maintained, which is a characteristic of the protein environment in which electron transfer occurs, and d constant. Moser and colleagues (1992) took the same analysis to a number of different biological and synthetic electrons. Their analysis showed that for each of the biological electrons checked, the values of ΔG ° and λ were equivalent, resulting in a maximum electron transfer rate for this reaction. In other words, for each certain distance between an electronic donor and anceptor in protein, evolution changed the characteristics of the protein environment of this electronic transfer to increase the reaction rate. From an evolutionary point of view, the speed of electronic transfer reactions is important because they contribute to the effectiveness of the reaction – in particular by minimizing the contribution of competitive, non-production reactions. Since the electron is transferred to the base of the main cellular reactions of biological energy transformations, the importance of optimizing these reactions is clear. Although moser and colleagues have written a book since 1992, his authors write as generalists, as evidenced by the following quote: Natural selection has shaped the current form of electronic transport proteins by applying the engineering principles we have outlined.... This biological plan outlines the main characteristics of the function of some of the most important electronic means of transport systems in nature and clarifies the design requirements for the construction of similar systems in the laboratory. (p. 802) It should not be taken into account that the formulation of modern evolutionary synthesis is the result of the cooperation of various specialists (e.g. geneticists Theodosius Dobjanski, ornithologist Ernst Mair, paleontologist George G. Simpson, botanist G. Ledyard Stebbins), all of whom have adopted a global evolutionary perspective designed to be all included. This enterprise was stimulated in part by the development of population genetics by Ronald A. Fisher, John B. S. Haldane and Sewall Wright, among others, between 1918 and 1932. However, it requires the cooperation of many specialists to solve many – if not all – conceptual and theoretical problems arising from the high degree of specialisation and weak lines of communication between at the beginning of the twentieth century (Mair 1982, Smocovitis 1996). Modern synthesis attempts to unite all biological sciences and illustrates the enormous importance of teaching scientists to see how their research fits into the bigger picture. Cultivating the specialist – generalist The following quote illustrates the importance of focusing on specific problems (the attitude of the specialist) and the importance of seeing how each solution fits into the grander scheme of things (the attitude of the attitudes of the fellowship). More refined, but also more durable for those who know enough to see them are two beautiful aspects of life: its unity and its diversity. (Dobjanski 1964, p. 114) The achievements of Darwin, Pasteur, and others show that these two attitudes are not mutually exclusive and that both should be cultivated and rewarded. The specialist is necessary to expand the body of knowledge within a discipline; generalists are needed to synthesize newly acquired knowledge and integrate it with previous knowledge. In this way, students should not be familiar with all the details of biology, but rather should move away from courses with an understanding of the inter walks that are integrated into modern biology and the ability to think critically and apply biological information to issues that are outside the scope of the subjects covered by the courses. But how are we going to achieve that? How do we train students to become generalist specialists? More broadly, how do we collect biological sciences? This final question motivates the American Association for the Advancement of Science, the National Science Foundation, and other stakeholders in training future biologists to publish a call to transform undergraduate biology education (Brewer and Smith 2011). In response to these efforts, four biological key areas were identified in a report developed by the National Research Council (NRC) Council on Science Education (NRC 2012). These areas are those found from molecules to organisms, ecosystems, heredity and biological evolution. Brewer and Smith (2011) also contains a chapter identifying seven basic concepts covering the whole science. These are models; cause and effect; scale, ratio and quantity; systems and models of systems; structure and function, stability and change. The NSC report (2012) is an important first step as it provides a model to bring biological sciences together. However, to paraphrase mathematician Samuel Carlin, who has made fundamental contributions to both game theory and biomolecular sequence, the purpose of the model is not to fit the available data, but to exacerbate our questions. Will the model developed by the Council of SNR for Science Education cultivate the specialist - a fellow? We believe that the answer is not mandatory. In our experience, introductory biology courses teach most, if not all the four biological areas and the seven cross-concepts, but they usually do not have an integrated approach. Blood circulation in animals is taught in one lecture, the movement of water in plants is taught in another lecture, and the main cellular processes that drive both are taught in another. The NSC model is a list of concepts to be taught, but does not provide a model for how these concepts can be integrated; the breadth of concepts does not translate into conceptual synthesis. Therefore, the critical question is how to learn biology. Recognition of basic concepts is an important first step, but it is equally important to communicate these concepts in an integrated way. The model that generally describes student and educational experience is one in which the breadth of science is introduced at the beginning, but with proceeds from the training, the educational experience becomes more specialized. However, our understanding and assessment of how biology unites (i.e. how basic biological concepts articulated with each other) are not usually taught in the classroom. Rather, it is collected through practical experience and self-knowledge outside the classroom or, more often than not, in a research environment where the ability to really understand information requires an integrative perspective. Recent studies in science education and cognition highlighted the benefits of shifting this integrative experience to coincide with the breadth of the introductory biological experience (e.g. NRC 2003). We need to teach biology in the context of the science process, with a comprehensive understanding that learning should start with common things that give context in order to understand all the details that are subsequently studied. Teaching teachers how to teach is not an easy task and, in our experience, there are equally effective teachers who have many different styles. If the three of us were asked to give the same lecture, it is likely that some of our students would not even recognize that our lectures dealt with the same topic. Therefore, we believe that there is no single way to teach each topic, but we also believe that any attempt to teach biology should be emphasized that basic biological concepts are interrelated, not only with other sciences. The transport of liquid in animals, plants, fungi and bacteria is a single concept and cannot be taught effectively without based on the concepts of adhesion, adhesion, bulk flows and passive diffusion. Equally ineffective in teaching energy flow in plants, animals, microbes or entire ecosystems without using the concepts of chemistry and physics and using the tools of mathematics (Nobel 2005, Wayne 2009, Niklas and Spatz 2012). It is unlikely that all biologists will agree with the main areas of biology identified in the 2012 SRC report or with the seven cross-concepts in science (Brewer and Smith 2011). What do we all have to agree on? We must assume that biology is one in theory from its basic concepts, but fragmented in practice, because the internading between these concepts is often not actively pursued. We have to accept that the degree of specialisation is likely to increase as the depth of our scientific knowledge grows, but we also need to accept the need to train students to have an integrative perspective that makes them think globally early in their academic experience and constantly appreciates the importance of this perspective as they become specialists. We need to train our students to be enthusiastic generalists in second place, and specialists secondly to be able to achieve a new (and truly all-inclusive) modern synthesis. References are quoted. . Global annual volume of peer-reviewed articles and sharing available through open access options. scholarship: Authority, community and sustainability in 2.0 years — Compendium of reports from the 12th International Conference on Electronic Publication held in Toronto, Canada. . . . . Temperature and dependence on $-\Delta G^\circ$ of electron transfer from BPh^- to QA in reaction center protein of rhodobacter sphaeroides with different QA quinones. Journal of the American Chemical Society : -. –.