BIOLOŠKO IZOBRAŽEVANJE V HITRO SPREMINJAJOČEM SE ZNANSTVENEM IN SOCIALNO-EKONOMSKEM KONTEKSTU

Andrew Moore

Vodja programa Znanost in družba pri Evropski organizaciji za molekularno biologijo, andrew.moore@embo.org

BIOLOGY EDUCATION IN A RAPIDLY CHANGING SCIENTIFIC AND SOCIO-ECONOMIC CONTEXT

Andrew Moore

Science & Society Programme Manager, European Molecular Biology Organization, andrew.moore@embo.org

Povzetek

Kot kažejo izkušnje Evropske organizacije za molekularno biologijo (EMBO), ki v zadnjih šestih letih organizira mednarodne delavnice za izobraževanje v biologiji, se biološko izobraževanje v Evropi sooča s številnimi resnimi težavami. Težave niso prisotne vsepovsod, vendar jih opaža velik del učiteljev (navadno večina) biologije na srednješolski stopnji v večini evropskih držav. Najpomembnejše težave so preobsežen in zastarel učni program, zastareli učbeniki, premalo časa za obdelavo posamezne snovi, nezadostno praktično delo, omejeno znanje biologije, dojemanje biologije kot neznanstvenega predmeta, neprimerne pedagoške metode, pomanjkljiva spodbuda k ustvarjalnosti in neodvisnosti učiteljev, nenavdušenost učiteljev, pomanjkanje stalnega izobraževanja učiteljev in seveda tudi pomanjkanje navdušenosti učencev za ta predmet, kar izvira iz mnogih prej naštetih problemov.

Kot organizatorji izobraževalnih delavnic obravnavamo učitelje v srednjih šolah kot znanstvenike, ker si kot znanstvenike predstavljamo ljudi, ki so profesionalno poučeni v znanosti in znanstvenih metodah in lahko znanost tudi predstavljajo drugim. Skupni cilj biologov je, izboljšati stanje omenjenih težav. Najprej se moramo osredotočiti na nekatera prednostna področja in šele nato bo sledilo izboljšanje tudi na drugih področjih. Na primer, če bi obravnavali učitelje biologije kot prave profesionalce, bi jim morali nuditi možnosti za razvoj njihove strokovnosti in znanja, kar pomeni seznanjanje z najnovejšimi dosežki znanosti, možnost rednega izobraževanja na strokovnem področju ter usvajanje novih metod dela. Raziskovalci in drugi znanstveniki na inštitutih in univerzah so ključni del teh izboljšav. Trenutno večinoma sodelujejo kot prostovoljci, ki prejemajo majhne finančne nagrade ali delajo celo brezplačno. Takšno dejavnost bi morali razširiti in ustrezno finančno nagraditi, če bi jo želeli ohraniti in razviti v skladu s potrebami. Konec koncev je glavni namen predstaviti pomen učiteljev in skrbeti zanje. Že samo to bi ogromno prispevalo k

izboljšanju morale in navdušenja učiteljev, spodbuditi pa je treba tudi njihovo neodvisnost in ustvarjalnost ter za to nameniti potreben čas v prenatrpanih učnih programih.

Kot da to ni dovolj težko, tem izboljšavam nasprotujejo smernice razvoja šolstva, ki še otežujejo vpeljevanje sprememb, vendar so te zato toliko bolj nujne: predstaviti je treba več in več znanja, vedno bolj se poudarja doseganje dobrih rezultatov na testih, ogromno je zunajšolskih virov znanja (kot je npr. internet), splošno pa je znano tudi zmanjševanje zanimanja za znanost med mladino.

Zadnja spoznanja nam omogočajo pogled na biologijo v okviru ostalega razvoja v znanosti in družbi. Od leta 1998 ima Evropa več objavljenih prispevkov v znanstvenih revijah kot ZDA, s čimer merimo produktivnost znanosti. Vendar pa nam to ne daje pravega razloga za samozadovoljstvo, ker raziskave kažejo, da tako rekoč v vseh evropskih državah učenci ne marajo znanosti v šoli, kariera v znanosti in tehnologiji pa se jim ne zdi privlačna. Kar se tiče biologije, smo lahko zaskrbljeni iz treh razlogov: 1) negativen odnos do znanosti pripelje učence do tega, da izberejo biologijo iz napačnih vzrokov (po liniji najmanjšega odpora, kot neznanstveni predmet); 2) druge znanstvene discipline, ki so pomembne v biologiji, so nezadostno predstavljene; 3) v svetu narašča število znanstvenih raziskav, kar naj bi bilo predvsem posledica razvoja biologije in novih raziskovalnih področij. Najmanj, kar lahko naredimo, je, da mladim predstavimo, kaj se novega dogaja v znanosti, da bi lahko cenili njen pomen.

V Evropi je produktivnost bioloških ved (po številu objav) večja od katerega koli drugega področja znanosti. Za to »eksplozijo informacij« v biologiji so zaslužne predvsem tehnologije različnih »-omik« in novih področij biologije, posledice pa je zaznati tudi v raziskavah in izobraževanju, saj postaja vedno pomembnejše, kako biologijo učiti v šolah ?- tako za tiste, ki bodo nadaljevali s študijem na univerzi, kot za tiste, ki bodo uporabniki proizvodov »nove« biologije v prihodnosti. Razdelitev ni nepomembna, ker je v zadnjem času biologija postala tako kompleksna, da so v nekaterih izobraževalnih sistemih (npr. v Veliki Britaniji) že razvili dva tipa učnega programa: znanost za nadaljnji študij in znanost za državljane.

Kar se tiče univerzitetnega študija in kasnejšega raziskovalnega dela v biologiji, je povezovanje različnih ved vedno bolj pomembno (transdisciplinarnost). V sodobni biologiji hitro prestopamo meje področij, razvijamo nove vede, iz povezovanj dobimo nove uvide in nova znanja. To zahteva odprtost misli in dobro znanstveno podkovanost na različnih področjih znanosti. Že v šoli bi lahko pri učnih urah biologije predstavili temeljne pojme »nove« biologije in tako širili miselni horizont tistih, ki so dovolj vedoželjni za nadaljnji študij. Sistemska biologija je eno od takih področij ?- poveže podatke iz ožjih raziskovalnih področij, da bi razumeli delovanje sistemov, od biosintetskih poti do ekosistemov. Nadalje, lahko predstavimo vrsto sodobnih dosežkov v biologiji, ki so družbeno zelo pomembni, od molekularne medicine, molekulske evolucije do najnovejše, sintetične biologije. Sistemska biologija je zanimiva tudi zato, ker z njeno uporabo lahko predstavimo dejstvo ?- čeprav nam računalniki omogočajo pridobiti ogromne količine podatkov, potrebujemo na koncu pronicljiv človeški um, ki spozna pomen in moč teh podatkov. Te bistre ume moramo začeti vzgajati že v šoli. Molekulska evolucija je kljub zapleteno zvenečemu imenu področje, ki ga z lahkoto razume večina ljudi in je lahka za poučevanje. Na kratko, geni in produkti genov

(beljakovine) mutirajo z določeno hitrostjo, kar nam omogoča njihovo uporabo kot nekakšnih molekularnih ur s hitrejšo ali počasnejšo hitrostjo tiktakanja, podobno kot so besede v evropskih jezikih mutirale iz skupnega izhodišča pred mnogimi stoletji. To nam potem omogoča risanje evolucijskih dreves, ki bolje opišejo sorodnosti med vrstami kot pa primerjalna anatomija, fiziologija ali embriologija. Vendar pa smo ob pregledu nacionalnih učnih programov biologije v evropskih državah ugotovili, da jih le 20 % vključuje poučevanje molekulske evolucije.

Rešitve za vpeljevanje nove biologije v šole niso preproste. Vključiti moramo pomembna področja in razviti določene ideje. Nekatere koncepte lahko v učni program vključimo preprosto, na primer molekulsko evolucijo, in jih uporabimo za predstavitev drugih pojmov, kot je molekularna medicina (prek genomike in proteomike, ki sta pomembni disciplini v raziskavah molekulske evolucije), pa tudi za osnovne stvari, kot je na primer vprašanje, zakaj so živalski modeli koristni za raziskave človeških bolezni. Druge teme bi lahko predstavili tako, da bi del učnega programa pustili odprtega za najnovejše dosežke znanosti; ta pristop so poskusno uvedli na Weizmannovem inštitutu v Izraelu. Prav tako je pomembno, da se učitelji redno srečujejo in diskutirajo o novih raziskavah, ki so predstavljene, recimo, v revijah Nature ali Science, ter o tem, kako bi njihova spoznanja vključili v svoja predavanja. Prav zaradi tega je tudi pomemben reden stik z raziskovalci. Na koncu smo spet prišli do pomena izobraževanja učiteljev. Učni načrti in učbeniki so le predmeti, pripomočki, ki bodo vedno zastareli, učitelji pa so živi prenašalci znanja, razmišljanja in navdušenja. Pomembno je spoznanje, da je redno dodatno izobraževanje učiteljev s pomočjo znanstvenikov na inštitutih in univerzah ključen del recepta za izboljšanje poučevanja biologije.

Summary

Across Europe there is a number of serious problems in biology education, as EMBO's experience of organising international biology education workshops for 6 years shows. These problems are not universal, but they are experienced by a large fraction of teachers (possibly most teachers) of biology at secondary level in most European countries. A non-exhaustive list includes: overloaded and outdated curricula, outdated text books, insufficient time to cover contents, insufficient "real" practical work, limitations of the scope of biology, the perception of biology as a "soft" subject, inappropriate pedagogy, lack of encouragement of teacher creativeness and independence, lack of teacher enthusiasm, lack of formal continuous teacher training, and, finally, a lack of student enthusiasm for the subject – which results from many of the preceding problems.

As organisers of education workshops, we treat secondary school biology teachers as scientists, because we consider a scientist to be someone who is professionally knowledgeable about science and its methods, and can communicate science. Our common goal as biologists, therefore, is to improve on all of the problems mentioned above. But there are certain priorities that should be concentrated on, and from which other improvements will follow almost automatically. For instance, if biology teachers are treated more as true professionals, then they must be provided with the means for professional development, and that means updates, or regular training opportunities, in their subject matter, its methods and pedagogy. Researchers and other scientists in institutes and universities are

a vital part of this improvement. Currently many are engaged in a voluntary capacity, with little or no financial recompense. This service, however, has to be financed and expanded, if it is to be sustained and meet demands. Ultimately it is all about demonstrating that teachers are important, and are cared for. That in itself can help enormously to improve teacher moral and enthusiasm, but independence and creativity have to be encouraged too, and the necessary time made available in crowded teaching programmes.

As if that weren't enough, these changes need to be made against trends that make them even harder, but even more necessary: an increasing amount of knowledge to be covered, more concentration on attaining good exam results, a bewildering array of non-curricular information sources (e.g. websites, Internet portals, etc.) and falling enthusiasm for science in general among young people.

The last observation leads us to view biology education in the context of other developments in science and society. From 1998 onwards Europe has a greater scientific output per year than the USA (number of publications in scientific literature). But we can hardly afford to be complacent (neither can the USA, in fact), because research shows that probably in all European countries, students of age 15 are not keen on school science, and do not see a career in science and technology as attractive. In terms of biology, we should be concerned for at least three reasons: 1) a negative perception of science leads students to choose biology for the "wrong" reason ("soft" option); 2) other scientific disciplines important to biology are underrepresented; 3) the rate of production of science globally is increasing, arguably driven by biology and recently emerged new research areas: at the very least we need to ensure that young people are aware of what is going on and can appreciate something of its significance. Indeed, in Europe, the productivity of the life sciences (in publications per year) is greater than any other scientific field.

The "information explosion" happening in biology – driven by "-omics" technologies and new branches of biology – has consequences for research and education, and puts more emphasis on the importance of how biology is taught in school – both for those wishing to study it at university, and those who will be consumers of the "new" biology in future. The division is not trivial, because biology has become so complicated these days that some educational systems (e.g. the UK) have developed two kinds of course: science for further study, and science for citizenship.

As far as university study, and later research, in biology are concerned, transdisciplinarity plays an increasingly important role. In modern biology, subject boundaries are rapidly being crossed, new disciplines made, new integrative insights and knowledge created. This requires minds that are open and knowledgeable in a number of scientific areas. Already at school level, biology classes can introduce some of the basic concepts of this "new" biology as a horizon-expander for those who are curious enough to want to go into tertiary study. Systems biology is one such area. It basically integrates information from smaller areas of research to understand how systems – from biosynthetic pathways up to environmental phenomena – work. Furthermore, it can be used to introduce a range of important modern advances in biology that have great societal relevance, from molecular medicine to molecular evolution. But it also enables a tantalising new technology: "Synthetic biology" Systems biology is also interesting from the point of view that it excellently demonstrates that whereas computers can help us generate massive amounts of data, it is ultimately bright human minds that will make the breakthroughs in understanding its significance and power. These bright minds need to be cultured starting at school.

Molecular evolution, despite its formidable-sounding name, is something that can be easily

understood by most people, and can easily be taught. Essentially it is the principle that genes and gene products (proteins) mutate at rates that allow them to be used as molecular clock with faster or slower rates of ticking – a bit like the way words mutate in European languages from a common stem, hundreds or thousands of years ago. This then allows us to draw evolutionary trees that are better at predicting the true relationship between species than comparative anatomy, physiology or embryology. However on inspecting national biology curricula across Europe, we find that in no more than 20 % of curricula is molecular evolution specified to be taught.

Solutions to introducing new biology to school teaching are not easy. They must incorporate several features, or explore certain ideas. Some concepts are so easily inserted into curricula (e.g. molecular evolution), that they should appear across the board. To save space, they can be used to introduce other concepts such as molecular medicine (via genomics and proteomics which are important in molecular evolutionary studies), and even things as basic as why animal models are useful in research on human diseases. Other topics might be introduced by making a part of the curricula "open" for new research: an experiment being tried at the Weizmann Institute in Israel. Of equal importance is that teachers meet each other regularly to discuss new research (e.g. reported in Nature or Science), and how they can mention it in their lessons; regular interactions with researchers can be very helpful in this respect. And finally this brings us to the matter of teacher training again. Curricula and text books are mere objects, and will always be out of date, but teachers are the living breathing transmitters of knowledge, thinking and enthusiasm. The importance of bringing teachers together for regular in-service training with the help of scientists at institutes and universities must be generally recognised as a critical part of the recipe for improvement.