oes a tomato have DNAin it? The average European adult would probably answer ‘no’—only a geneticallymodified tomato has DNA in it—whereas the average European secondary schoolpupil would most likely answer ‘of course’. Given that children and youngadults in secondary and higher education have a unique opportunity to developcritical thinking as well as assimilating facts, this chance must be betterexploited to open their minds to the latest developments in science. Not onlywill it help many of them to get a job and contribute to the prosperity ofEurope, but it will help all of them to understand better the fast-changingworld we live in. How well do we educate the youth of Europe in biology?According to TIMSS, the Third International Mathematics and Science Study,Europe is on average slightly less successful than the USA (see Table TableI).I).But is such a study really meaningful? Surely what is more important is thequality of scientists that the education system produces(http://www.uni-giessen.de/~gf1002/vdbiol/timss2.html). Thus, instead oflooking at the beginning of the life-long process of learning and discovery,perhaps we should focus on high schools and universities. And this is where theproblems borne in secondary and higher education come home to roost. ‘No onehas taught them [PhD students] how to think,’ remarked Jorge Moscat from theCBM Severo Ochoa in Madrid, ‘in the first few years [in the lab] they need tobe re-educated.’ And his group attracts some of the most gifted graduates inSpain, he said.

At the heart of the problemis an over-concentration on the learning of isolated facts and too littleintegration of mutually beneficial fields such as biochemistry, physiology,molecular biology, plant and animal sciences. For example, no serious biologistwould argue that a purely molecular approach to solving biomedical problems islikely to succeed. The study of genomics has unequivocally demonstrated theneed to integrate molecular studies with physiological and whole animalstudies. However, as might be expected from the time-lag between developmentsin research and those in education, even at undergraduate level there is apreoccupation with molecular reductionism at the expense of integrativeapproaches. In a sense, this is a success story because it proves that the teachingestablishment enthusiastically adopts important developments. But an integratedapproach to biology teaching naturally breeds greater problem-solving ability,a quality that appears lacking in recent graduates. The problem of a lack ofintegration is also a horizontal one between all of the natural sciences. AsChris Leaver at the Department of Plant Sciences at Oxford University noted, inaddition to many other shortfalls of the education system, biology teachersoften place too little emphasis on mathematics and the physical sciences. Ascomputing and mathematics become an increasingly important tool in theinterpretation of biological data, so the need increases for biologists who areas happy devising algorithms as they are planning experiments in the lab.Ironically, among 16- to 18-year-olds taking biology in the UK, over half donot study mathematics or a physical science. This is one of the problems thatthe Royal Society, an organisation that collaborates with the BritishAssociation for the Advancement of Science to improve public understanding andeducation of science, intends to tackle in its recently devised educationprogramme. The education system in the UK, where a new curriculum for 16- to18-year-olds is just being introduced, has drawn widespread criticism for itsscience curriculum. But in terms of the graduate biologists it produces, itneed not hang its head in shame. In comparison, German graduates fare muchworse in skills such as reading and assimilating research papers. They are trainedin ‘following recipes’ rather than creative thinking, noted Patricia Kahn,editor of the IAVI Report, a publication of the International AIDS VaccineInitiative, who taught graduate students at the University of Heidelberg. Sheadded that it is regrettable that German Scientists are stifled by the ‘factorysystem’ in which they are reared—a learning

framework built around thememorisation of facts and practically no contact with professors. In secondaryschool education, Germany could also do better, but here at least there is atleast one energetic initiative underway: The ‘Heidelberg Life-Sciences Lab’(http://www.brains.de and http://life-science-lab.xmachina.de), brain child ofThomas Schutz, a biologist working at the Krebsforschungszentrum, who iscoordinating an engaging calendar of events. In addition to opportunities forthe public to learn more about science, Schutz, in collaboration withinterested scientists, has devised a holiday academy. A group of schoolchildren selected in competition with others will work for a week on projectsof their own design in a genuine research laboratory. The indefatigableHeidelberg biologist also plans a seminar to bring scientists and teacherstogether and to discuss continuing education of biology teachers, a matter ofsome urgency. For continuing education brings new ideas and inspiration intothe classroom. It is an uncommon pupil who is not affected by a teacher’senthusiasm for his or her subject. It is an all too often heard complaint ofparents that their children simply are not interested in school subjects. Andit is depressing to think that on entering school, the fascination that mostchildren have for things that creep, crawl and wriggle can turn into apathy.Class sizes are clearly one reason; teachers cannot give each child enoughattention, and this is where multimedia can help. However, the hardware neededto equip a school satisfactorily is in general too expensive for a publiclyfunded education system. A recent report revealed that only 6% of PCs in Germanschools have a CD-ROM—the figure elsewhere in Europe can hardly be better.Fortunately, many excellent Internet sites—often hosted by museums and visitorcentres—offer an abundance of teaching resources for free. Predictably, most ofthe web resources in biology are hosted by US institutions and universities.Inspiring and educating young scientists is something that we cannot leave tochance, given the indisputable connection between scientific research andeconomic growth. In Israel, whose economy is firmly based on science andtechnology, this link is clear to those officials responsible for education.That is why in recent years a minor revolution has taken place in theireducation system, inspired by a report from a national committee, headed byProfessor Haim Harari, President of the Weizmann Institute. Not surprisingly itaddressed the very problems that still trouble Europe. First, the curriculawere rewritten to place more emphasis on integration between the science andtechnology curricula. Secondly, teachers, in growing numbers, participate incontinuing education through a network of regional training centres, which theyattend one day a week. For this, they are rewarded with an increased salary.Teachers are important after all, as we have yet to recognise in Europe.Finally, a core curriculum is being devised for all subjects, not just thesciences. The Israeli Ministry of Education liaises very closely with academicsin universities and provides them with a budget for the development of teachingmaterials. However, as Benjamin Geiger, Professor at the Weizmann Institute,who was involved in the implementation of this reform, conceded, Israel issmall—1.2 million children attend school—and its education system iscentralised, and hence activities can be coordinated relatively easily. ‘Butthe implementation of such a comprehensive reform is a slow and difficultendeavour,’ he added, ‘and it is still way too early to evaluate its success.’Since Europe is large, there is an even greater need for a similar revolution.But given that many countries do not yet have a national curriculum, thepossibility of a pan-European curriculum seems a little remote at the moment.The task of planning curricula and teaching them is not likely to becomeeasier. An ever-increasing number of factors need to be considered. The expertpanels who design curricula must include many different professionals, amongthem practising scientists, educators, social scientists and ethicists. The newknowledge and concepts that arise in research must be complemented byconsideration of their ethical, social, environmental and economic impact.These are topics that must be tackled not only in science, but across the wholecurriculum, as the Wellcome Trust recently recommended in its concepts for anational curriculum in England. What a challenge. Teachers have never been sovaluable.

CAN THEY THINK FOR THEMSELVES?