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WHAT DO THE ELECTRON MICROSCOPES "SEE"?

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Announcement. The achievements of the experimentalists in microworld inhabitant photographing are impressive. But almost all of them are mistaken in the determination of resolution of their microscopes. The new theory of microworld facilitates an interpretation of the microworld structures being photographed, makes it possible to identify the contradictions in the assessment of the electron microscope resolution and to find its value being close to reality.

It is known that the light range photons with the average wavelength of $5.0\cdot10^{-7}$ m, which allow our eyes to see an object with the dimension of nearly $\approx 0.20\cdot10^{-3}$ m, bring information to our eyes. It appears from this that the minimal quantity of the photons, which bring an image of the object in the form of a point with the radius of $0.10\cdot10^{-3}$ m to our eyes, is $0.2\cdot10^{-3}/5.0\cdot10^{-7} = 0.40\cdot10^{-4}$ pieces.

Forty years ago, the electron microscope creators announced that their microscopes distinguish the objects with the dimension of one Angstrom unit, i.e. $1.0\cdot10^{-10}$ m. It was reported that the attempts to improve this index failed. Why?

Let us assess authenticity of resolution of the electron microscope, with the help of which the photos of the nanotubes have been obtained (Fig. 1, a). If we regard with confidence a scale vertical line of 1 nm (10^{-6} m) being presented in Fig. 1, a, and suppose that the cross-sections of the nanotubes in this Figure are ten times as small than the scale line, it will mean that resolution of the electron microscope at the given photo (Fig. 1, a) is $\approx 10^{-7}$ m. If an object is of smaller size, this electron microscope fails to see it.

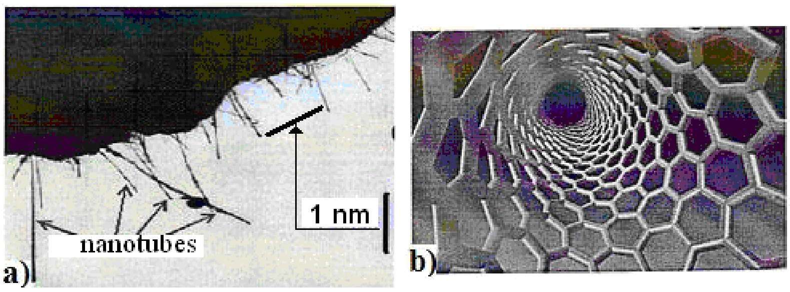

Fig. 1: a) photo of the nanotubes; b) picture of the nanotube

In order to check authenticity of the electron microscope resolution, it is necessary to know the actual dimensions of at least one inhabitant of microworld. The hydrogen atom is the main candidate to this part, because it functions as a connecting link between the atoms in the molecules.

But the orthodox theories have not made it possible to determine any dimension of the hydrogen atom, because they represent it in the form of a spherical cloud, which has no clear borders. The new theory of microworld has revealed a structure of the hydrogen atom and has made it possible to calculate its geometrical parameters. A length of the atom as a connecting link, which unites the atoms into molecule, is the main one among them. According to the new theory of microworld, the electrons of the atoms interact with the protons of the nuclei linearly, not orbitally. This makes it possible to use Coulomb's law for a calculation of the hydrogen atom length [1].

Coulomb's law makes it possible to determine a distance between the proton and the electron of the hydrogen atom when it resides at any energy level *n*. As binding energy of the proton with the electron at the time of its stay at the first energy level is equal to ionization energy of the atom $E_1=E_i=e^2/R_1=13.6\ eV$, we shall have the following equation when *n*=1 (Table 1) [1]:

$$R_1 = \frac{e^2}{4\pi \cdot \varepsilon_o \cdot E_1} = \frac{(1.602 \cdot 10^{-19})^2}{4 \cdot 3.142 \cdot 8.854 \cdot 10^{-12} \cdot 13.598 \cdot 1.602 \cdot 10^{-19}} = 1.058 \cdot 10^{-10}\,m. \quad (1)$$

If we put $E_i = E_1 = 13.6\ eV$ and binding energies E_b resulting from Table 1 when *n*=2, 3, 4 …. in the formula (1), we shall have theoretical distances between the proton and the electron of the hydrogen atom when the electron resides at various (*n*) energy levels (Table 1).

Table 1. The hydrogen atom spectrum, the binding energies E_b between the proton and the electron and the distances R_i between them [1]

Values	n	2	3	4	5
E_f (exp)	eV	10.20	12.09	12.75	13.05
E_f (theor)	eV	10.198	12.087	12.748	13.054
E_b (theor)	eV	3.40	1.51	0.85	0.54
R_i (theor)	$\cdot 10^{-10}\,m$	4.23	9.54	16.94	26.67

In the hydrogen molecules, the binding energies of the electrons with the protons acquire the values between the binding energies, which correspond to two energy levels of the atomic state (Table 1). The values of these energies depend on the temperature of the medium, in which the atoms or the molecules being photographed are situated. The analysis shows that at the room temperature the electrons of the hydrogen atoms in its molecules are approximately between the second and the third energy levels, which correspond to their atomic state. According to Table 1, the binding energy of the electron of the hydrogen atom with its proton at the time when it functions as a link, which unites the atoms into molecules, is nearly $E_b \approx 2.0\ eV$. If we put this value in the formula (1), we shall get the length of the hydrogen atom as the link, which unites the atoms into the molecules. It will be $\approx 7 \cdot 10^{-10}\ m$.

Thus, we know the approximate theoretical distance ($\approx 7 \cdot 10^{-10}\ m$) between the electron and the proton of the hydrogen atom when it functions as the connecting link between the atoms in the molecules at the room temperature. It affords ground to use this distance for an assessment of the resolution of the microscopes, which photograph the atoms and the molecules.

Let us analyze resolution of the Japanese scanning electron microscope, which has been used by the team of the Tokyo University investigators headed by Professor Yuichi Ikuhara in order to capture an image of the hydrogen atom *H* and the vanadium atom *V* separately as they think (Fig. 2, a) [2].

It is unclear why the Japanese scientists think that the dark spots at their images correspond to the atoms of hydrogen and vanadium. On the contrary, the light spots at the images correspond to the above-mentioned atoms. The scale line *M* at the photo (Fig. 2, a) corresponds to two Angstrom units. The length of this line is equal approximately to the distances between the dark spots, which, according to the Japanese investigators, are the atoms of hydrogen and vanadium.

A theoretical model of the hydrogen atom is shown in Fig. 2, c. Let us pay attention to the fact that the size of the electron e is by three orders of magnitude (1000fold) larger than the size of the proton *P*, and the length of the hydrogen atom $\approx 7 \cdot 10^{-10}\ m$ is by two orders of magnitude larger than the size of the electron. Let us consider if we can use a theoretical value of the hydrogen atom as a reference length in the analysis of the resolution of the electron microscopes. For this purpose, let us present the length of the hydrogen atom as compared with the length of the scale line. As a result, the length of the hydrogen atom will be as the length, which is shown in Fig. 2, b.

In the magnification being presented, the length of the scale line *M* in Fig. 2, a, is equal to 15 mm. It corresponds to $2{\cdot}10^{-10}$ m. The theoretical length of the hydrogen atom (Fig. 2, c) is $7{\cdot}10^{-10}/2{\cdot}10^{-10}$=3.5 times as much. It appears from this that the length of the hydrogen atom in the scale of the scale line M in Fig. 2, a, should be 15x3.5=52.5 mm (Fig. 2, b).

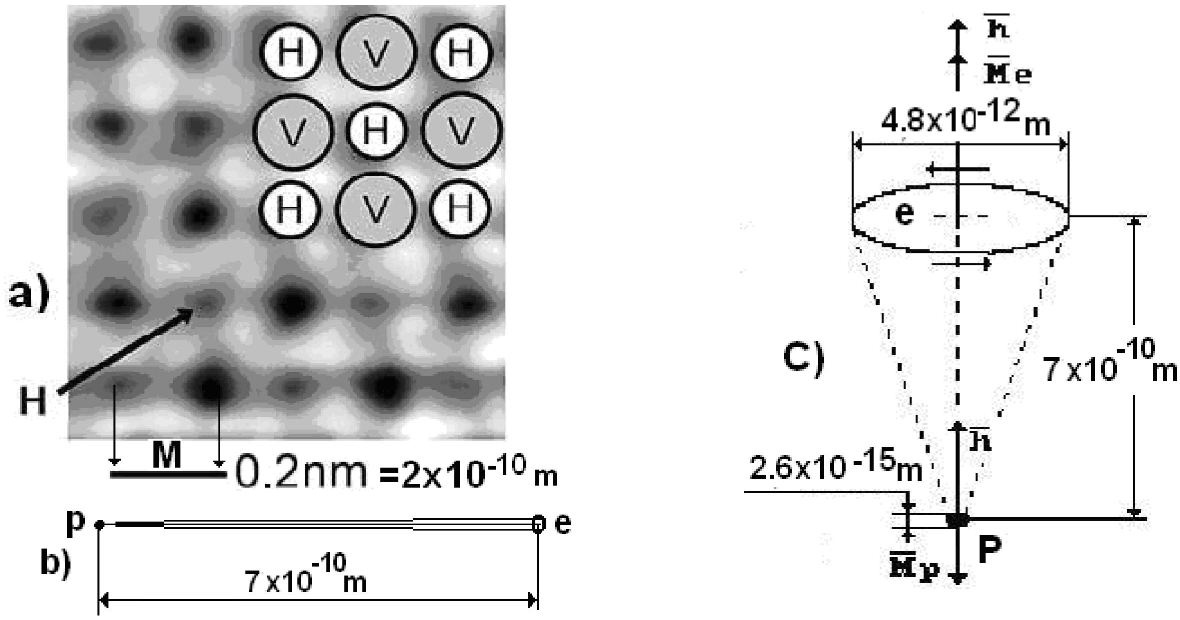

Fig. 2: a) the Japanese image, in which the hydrogen atoms are marked by symbol H, the vanadium atoms are marked by symbol V, the scale line is marked by symbol M; b) the model of the hydrogen atom in the scale of the scale line m; c) the theoretical model of the hydrogen atom and its size in an unagitated state

Later on, we shall show that the distance between the dark spots in the photo (Fig. 2, a) is equal to the total length of three hydrogen atoms minimum, i.e. 52.5x3=157. 3 nm. If we take into account that the length of the scale line in Fig. 2, a, is 15 mm, we shall get at least a tenfold overstatement of the Japanese microscope resolution. The Japanese investigators were too hasty in the publication of the information, according to which they managed to capture the image of the hydrogen atom; their microscope fails to see the hydrogen atoms.

Let us analyze the electron photos of the European investigators [2]. The image of graphene, which has been obtained by the European investigators, is the most outstanding image made with the help of the electron microscope (Fig. 3, a). Computer visualization of graphene is given in Fig. 3, b; it proves a linear interaction of the electrons of the carbon atoms in the formation of the carbon cluster, graphene. The white spots in the photo (Fig. 3, a) are the carbon atoms, which consist of the nuclei and its six electrons. The distinct hexagonal structures made of carbon atoms (Fig. 3, a and b) prove the presence of the linear bonds between them. These bonds realize 3 valence electrons (out of 6) of each carbon atom. It results from the theoretical structure (Fig. 4, c) and the theoretical structure of graphene (Fig. 7).

In order to check authenticity of the value $0.14{\cdot}10^{-9}$ m=$1.4{\cdot}10^{-10}$ m, which is given at the image (Fig. 3, a) by the authors, it is necessary to have the structure of the carbon atom and its spectrum. A visual structure of the carbon molecule is given in Fig. 4; a spectrum of the first electron of the atom (Fig. 4, b) is given in Table 2 [1], [3].

Table 2. Spectrum of the 1st electron of the carbon atom

Values	n	2	3	4	5	6
E_f (exp)	eV	7.68	9.67	10.37	10.69	10.86
E_f (theor)	eV	7.70	9.68	10.38	10.71	10.88
E_b (theor)	eV	3.58	1.58	0.89	0.57	0.39

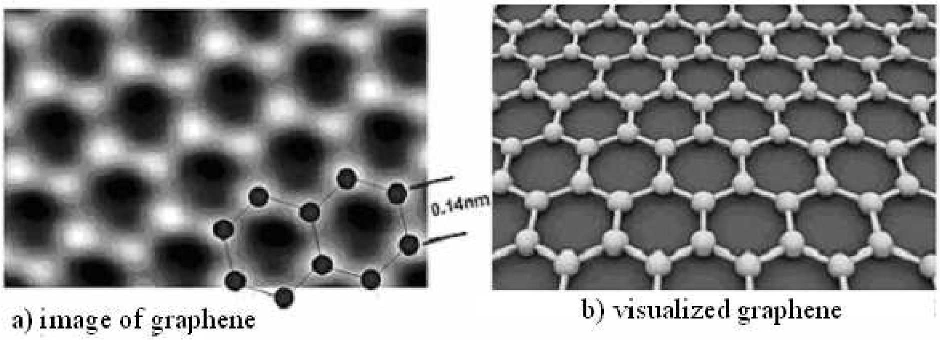

Fig. 3. Image of graphene and its computer visualization

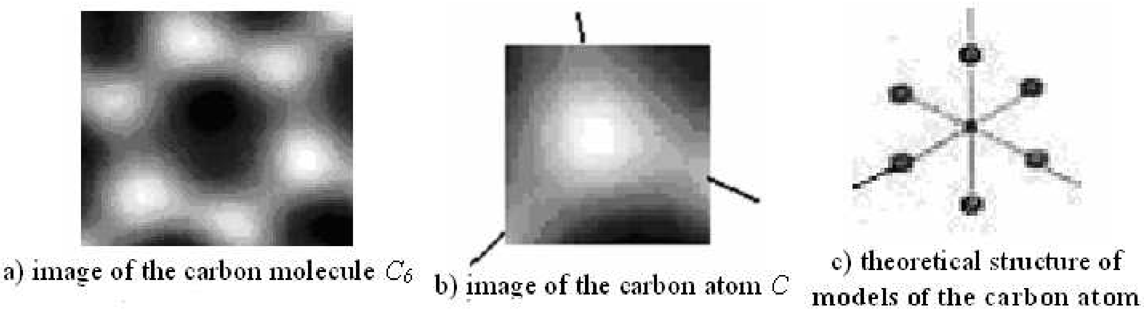

Fig. 4. Photographical structures of the carbon molecule and the carbon atom and the theoretical

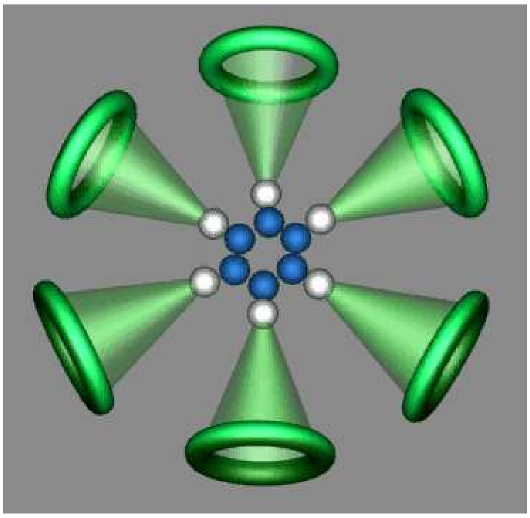

Fig. 5. Model of the carbon atom

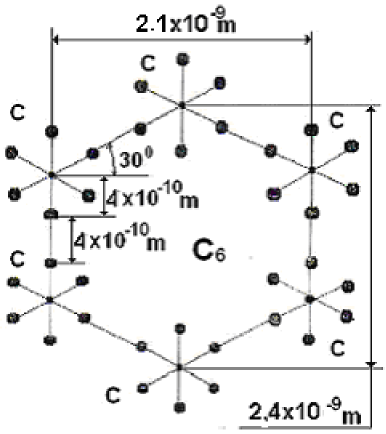

Fig. 6. Molecule of carbon C_6

It appears from the new theory of microworld that if all electrons are in the atom, their binding energies with the protons are changed in the same way as the binding energies of the electron of the hydrogen atom with the proton. Taking it into account and having ionization energy E_H=*13.60 eV* of the hydrogen atom, we can calculate binding energy E_b of any electron l of any atom, which corresponds to any energy level n, according to the formula [1]

$$E_b \approx \frac{E_H \cdot l^2}{n^2} . \qquad (2)$$

As the flat carbon atom (Fig. 5) is a symmetrical one, the binding energies of each out of six electrons of the carbon atom with the protons of the nuclei (when the electrons are at the second energy levels) will be equal to

$$E_b \approx \frac{E_H \cdot l^2}{n^2} = \frac{13.6 \cdot 1^2}{2^2} = 3.4eV \ . \qquad (3)$$

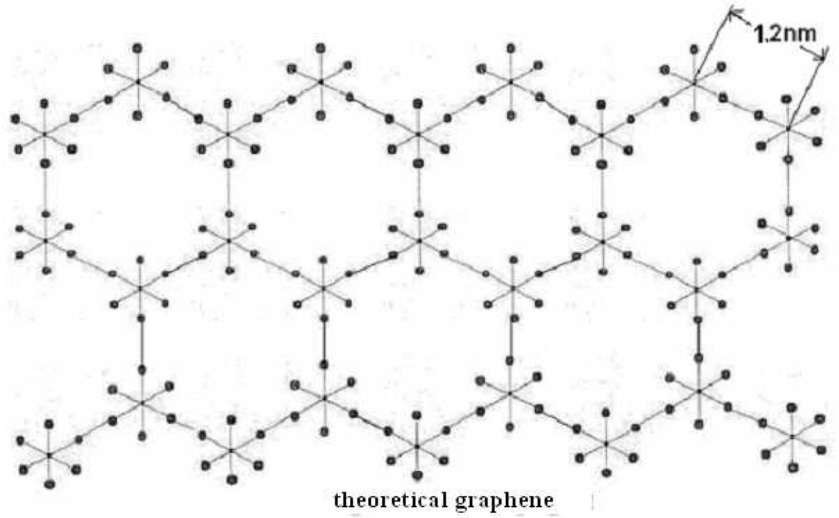

Fig. 7. Theoretical structure of graphene

Taking it into consideration, the distances between the protons of the nuclei (Fig. 5) and the electrons will be equal to

$$R_1 = \frac{e^2}{4\pi \cdot \varepsilon_o \cdot E_1} = \frac{(1.602 \cdot 10^{-19})^2}{4 \cdot 3.142 \cdot 8.854 \cdot 10^{-12} \cdot 3.4 \cdot 1.602 \cdot 10^{-19}} \approx 4 \cdot 10^{-10} m. \qquad (4)$$

The information being obtained makes it possible to determine the dimensions of the molecule of carbon C_6, which is given in Fig. 6. They result from the spectra of this chemical element, which is given in Table 2.

Thus, an actual distance between the white spots (the carbon atoms) is $1.2 \cdot 10^{-9}$ m (Fig. 7), not $0.14 \cdot 10^{-9}$ m as the authors of this image think. They have overstated resolution of their microscope 10fold. Nevertheless, we should recognize the achievements of the experimentalists as very important ones for science and the experimental value $0.14 \cdot 10^{-9}$ m, which differs from the theoretical one $1.2 \cdot 10^{-9}$ m as insignificant. It is possible to reduce the discrepancies between the theory and the experiment if the temperature of the microworld objects being photographed is taken into consideration, but so far we do not know the temperature, at which the microworld inhabitant images have been captured.

Let us pay attention to the misty spiky protrusions, which are present along the external contour of the benzene clusters C_6H_6 being photographed (Fig. 8, a and c). They are the hydrogen atoms. The electron microscope fails to see them. In the theoretical benzene molecule (Fig. 8, e), the hydrogen atoms are presented in the form of the dots and the lines, which connect the electrons of the carbon atoms and the hydrogen atoms. A vivid connection between the image of the benzene cluster (Fig. 8, a and c) and its theoretical structures (Figs. 9 and 10) proves that the electrons in the atoms interact with the protons of the nuclei linearly.

A comparison of the theoretical models of the benzene cluster (Fig. 10) with its images (Fig. 8, a and c) makes it possible to congratulate the European experimentalists who have reflected visualization (Fig. 8, b and c) of their images precisely. Certainly, they have not a complete command of the new theory of microworld; that's why they have presented the carbon atoms and the hydrogen atoms in the form of the balls, which are interconnected by the linear bonds. It is a pity that the investigators have failed to give information concerning resolution of their electron microscope. Let us show how the new theory of microworld decodes the intent of information in these images and determines resolution of the electron microscope, which has been used for the image capture. For this purpose, let us give a theoretical model of the photographed benzene molecule with the dimensions, which are calculated easily if the length of the hydrogen atom is known (Fig. 8, e). In Fig. 8, d, one can see the dimensions of the elements of the structure of the photographed benzene cluster resulting from the dimensions of the benzene molecule C_6H_6 (Figs 8, e and 9). They are the microscope resolution indices [6].

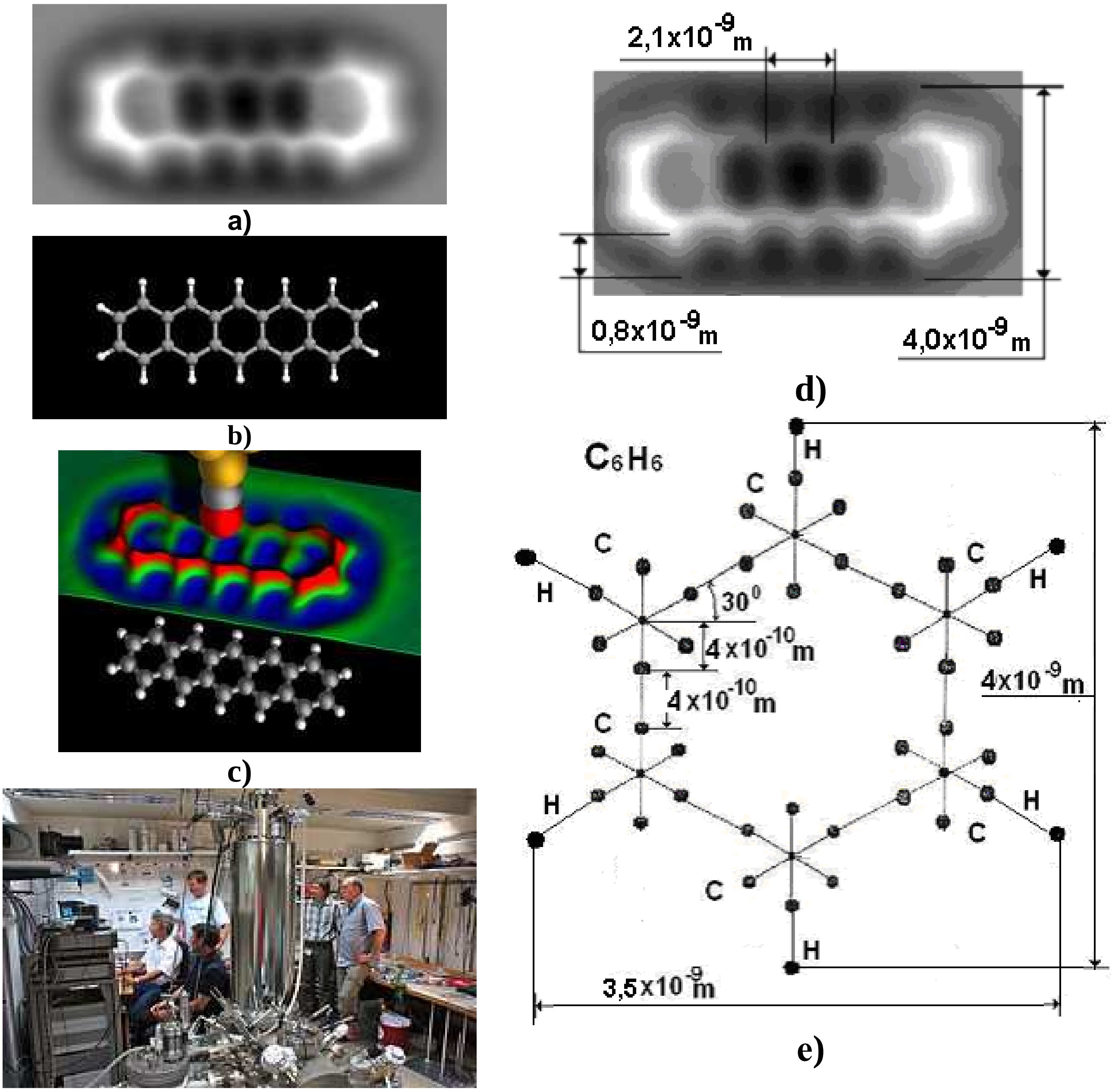

Fig. 8. Achievements of the European experimentalists in cluster photographing

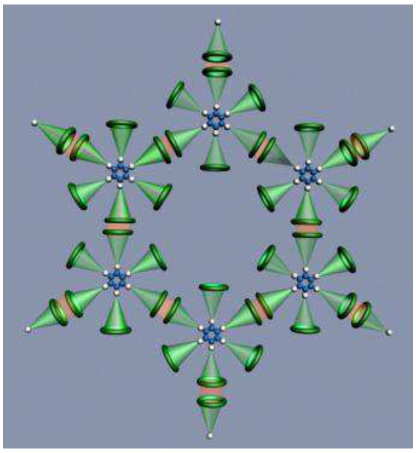

Fig. 9. Structure of the benzene molecule [8]

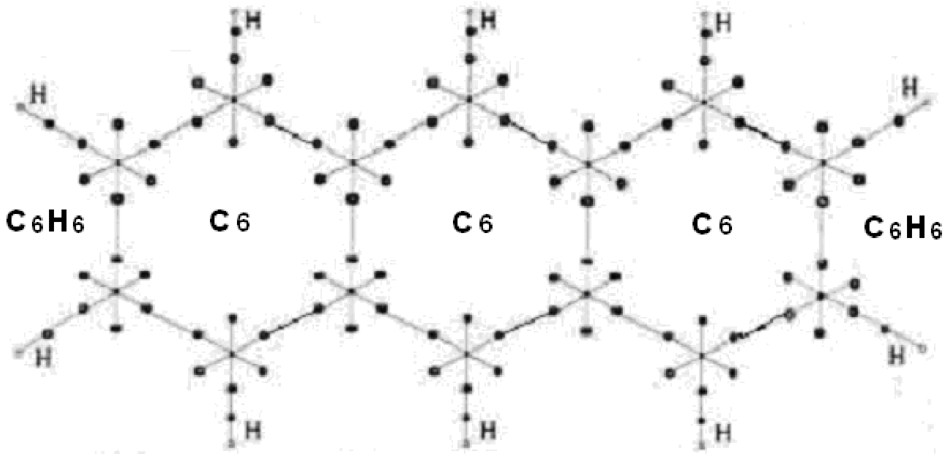

Fig. 10. Theoretical structure of the benzene cluster

CONCLUSION

The statements of the electron microscope producers concerning the fact that their microscopes make it possible to capture images of the separate atoms are premature. Nevertheless, their achievements are impressive, but unproductive without the new theory of microworld, which "sees" the microworld inhabitants with resolution by 6 to 7 orders of magnitude better than the achievements of the experimentalists and facilitates an interpretation of the information, which is obtained with the help of the electron microscope [6].

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