A

A Brief History of Cryomedicine

> The farther backward you can look, the farther forward you can see.
>
> *Sir Winston Churchill*

This appendix contains a brief summary of the cryomedicine development. A more comprehensive treatment of the history of cryosurgery could be found in the following papers [205,334,516,782,804,874] and of cryosurgery equipment in [262,672,804].

Origins of cryobiology could be traced down to ancient Egyptians; probably the first scientific account of this science is the monograph published by Sir Robert Boyle "New Experiments and Observations Touching Cold, Or, An Experimental History of Cold, begun. To which are added An Examen of Antiperistasis, And an Examen of Mr. Hobs's Doctrine about Cold. Whereunto is annexed An Account of Freezing, brought in to the Royal Society, by the learned Dr. C. Merret, a Fellow of it. Together with an Appendix, containing some promiscuous Experiments and Observations relating to the precedent History of Cold." (London, Richard Davis, 1683).

The effect of water supercooling was discovered by Daniel Gabriel Fahrenheit in the beginning of the eighteenth century [381]. Experiments on the freezing of cells started in the end of eighteenth century. In 1776, Spallanzani noted that spermatozoa, cooled in snow, became inactive but were revived on warming [219].

In the middle of the nineteenth century, Julius von Sachs [261] developed a low-temperature stage for his microscope that allowed him to detect the dehydration of cells in the presence of the extracellular ice. Hans Molish was the first to study in the end of the nineteenth century the formation of the intracellular ice and to measure the cell volume change [262].

Experiments in the middle of the nineteenth century by Michael Faraday who achieved a temperature of 163 K by mixing solid carbon dioxide and

alcohol under vacuum, the development in 1877 by Cailletet of France and Pictet of Switzerland of adiabatic expansion systems for cooling gases and in 1892 by Dewar of Great Britain the first vacuum flask for storage and handling of liquefied gases as well as invention in 1895 by Linde of Germany and Hampson of England continuously operating air liquefiers based on the Joule–Thompson effect provide the technical support for the cryomedicine development.

In 1833, Openchowski reported using a low-temperature system for freezing portions of the cerebral cortex of dogs, however, not for therapy but as a tool for inducing lesions in the brain for research.

Twentieth century witnessed a rapid development of cryobiology related to the progress of the cryogenic equipment (closed systems based on liquid nitrogen evaporation or on the Joule–Thomson effect – cooling by rapid gas expansion from a high to a low pressure zone through a small orifice), developments of monitoring techniques, extension of the list of diseases that have been successfully treated by cryomedicine, and consolidation of research by foundation (simultaneously in 1964) of two major scientific societies in this field – The Society for Cryobiology (http://www.societyforcryobiology.org/mc/page.do) and The Society for Low Temperature Biology (http://www.sltb.info/).

Vitrification as the preservation method was suggested by the Jesuit priest B.J. Luyet in 1937 [598] and demonstrated by him (in collaboration with R. Hodapp) a year later for the frog spermatozoa vitrified in liquid air after dehydration in the solution of sucrose [600]; the fundamental monograph "Life and Death at Low Temperatures" by B.J Luyet and P.M. Gehenio was published in 1940. The authors described extensive experiments on the freezing of a wide range of organisms from bacteria and nematodes to tissues isolated from higher organisms, including frog muscle and mammalian erythrocytes. Luyet and Genehio concluded that frequently cellular damage and death were caused by the ice formation.

In 1949, Polge et al. reported the first use of glycerol as a cryoprotectant. This discovery has started a fast development of cryopreservation techniques and cryoprotective solutions. A cryopreservation was reported for the fowl spermatozoa suspended in a glycerol–albumen solution surviving freezing to $-79°C$ and later for the bull spermatozoa [776].

Establishment of human sperm banks suggested in 1866 by Mantegazza [548,731] was realized a century later almost simultaneously in France (Centre d'Etude et Conservation du Sperme, 1973) and USA (American Association of Tissue Banks, 1976).

Human embryos are now routinely cryopreserved as an adjunct to other techniques of assisted reproduction technology (ART), but still this approach remains the secondary one: babes born from cryopreserved embryos represent less than 8% of the total of ART babies born [509].

A.1 Cryosurgery

James Arnott of Aberdeen [101] was probably the first to apply the extreme cold locally for anesthesia as well as for the pallation of tumors in the breast and the uterine cavity and the destruction of the tissue using a mixture of salt and crushed ice [79]. He used a water cushion cooled by the flow of a solution from a reservoir of brine. The cushion was applied to accessible tumors, which were frozen to temperatures of about $-24°C$ with no hemorrhage.

His work was published by J. Bennet of Edinburg in his book "Cancerous and Canceroid Growth" (1846).

Campell White of New York and William Pusey of Chicago were the first to use for treatment cotton swabs dipped in liquid air and solid carbon dioxide (carbon dioxide snow or carbonic acid snow), respectively. C. White used liquid air for the treatment of a large range of diseases, including lupus erythematosus, herpes zoster, chancroid, warts, varicose leg ulcers, carbuncles, and epitheliomas. W. Pusey recognized the low scarring potential of cryosurgery although he attributed this to regeneration of residual epidermal cells rather than to collagen's resistance to cold.

After liquid oxygen became commercially available, it began to be used in the treatment of skin diseases in 1929. However, since liquid oxygen is a fire hazard, it has never become a popular cryogen for cryosurgery. In the early 1940s, P.L. Kapitsa in the SU and Collins in the USA began developing commercial techniques for large-scale liquefaction of hydrogen and helium, with liquid nitrogen as an abundant and low-cost by-product. Soon after liquid nitrogen became readily commercially available, Allington introduced it in clinical practice in 1950. The liquid nitrogen was applied with a cotton swab, and soon became common in the treatment of verrucae, keratoses, and various non-neoplastic lesions.

During the early part of the twentieth century cryosurgery was primarily used to treat dermatologic and gynecological diseases. Treatment of deep tissues was pioneered by a neurosurgeon Temple Fay of Philadelphia [874] using a self-made closed system in 1938 for the treatment of advanced carcinoma, glioblastoma, and Hodgkin's disease. M.J. Gounder and collegues were the first to use cryosurgery for urological disorders in 1960s.

A number of cryogens were used for medical applications, including dichlorodifluoromethane (Freon-12), with the boiling point $-29.8°C$, solid carbon dioxide ($-79°C$), liquid nitrous oxide ($-88.5°C$), liquid air, and liquid nitrogen ($-195.8°C$).

A.1.1 Cryosurgery Equipment

> Build a better mousetrap and the world will beat a path to your door.
>
> *Ralph Waldo Emerson*

> Having a better violin is a necessary but not a sufficient condition for making a better music.
>
> *E.J. Post*

Sometimes no cryosurgery equipment at all is necessary: for the treatment of the open tissues such as the malignant bone tumor the so-called direct pour (open system – pouring liquid nitrogen through the stainless-steel funnel into the tumor cavity) method [624] could be used. However, even in this case exploitation of the technological advances (pressurized spraying of liquid nitrogen, a semi-open system [221]) is preferable, since it allows to greatly reduce various complications (skin necrosis, delayed healing, nerve injury, etc.) due to the rapid evaporation of liquid nitrogen from the cavity [221].

Probably the first cryomedicine system was designed by J. Arnott in the middle of the nineteenth century. It consisted of a waterproof cushion applied to the skin, two long flexible tubes to convey water to and from the affected part of the patient, and a reservoir for the the ice/water mixture with a pump [205]. Using salt/ice mixture, Arnott achieved temperature of $-24°C$. For this device Arnott was awarded a medal at the Great Exhibition of London in 1851.

Various techniques were used to administer cold, including precooled metal blocks, precooled needles, dry ice applications, thermoelectric methods, and cryogenic heat pipes [672]. Solid copper cylindrical disks were cooled by immersion in liquid nitrogen before application to the skin. These cylinders by far exceed the cotton applicators in thermal capacity and heat exchange characteristics. Additional effect follows from the pressure exerted on the lesion that reduces the blood flow and related heat source. This approach allowed to double the depth of the tissue destruction to 4–5 mm.

A spray for cryosurgery was invented by a dermatologist H. Whitehouse of New York in 1907. He studied the effects of liquid air on normal skin and treated epitheliomata, lupus erythematosus, and vascular naevi. J.T. Bowen and H.P. Towle reported the successful use of liquid air for vascular lesions in 1907. Liquid nitrogen spray developed by Torre in 1965 was later modernized by S. Zacarian, who suggested the interchangeable tips allowing variation of the spray diameter and designed a hand-held device.

Close systems based on liquid nitrogen were introduced by I.S. Cooper and A. Lee in 1961 [203, 204]. Low temperature was achieved by evaporation of liquid nitrogen in a hollow insulated metal probes close to the tip attached to a circulatory pump. Liquid nitrogen transport to the tip is provided by the use of the so-called *Leidenfrost flow* (droplet film-boiling flow). The heat transfer from the liquid nitrogen to the tube wall in Leidenfrost flow is very low because liquid droplets are separated and thermally insulated from the wall by gas, thus little coolant is boiled off during transport to the tip.

A totally closed system allows the surgeon apply the cold to any part of the body accessible to probe. Later Cooper modified his original cryoprobe by adding a heating element that facilitates probe removing from the tissue after freezing, relieving the surgeon from the need to use special tricks such as flushing with saline to assist the detachment of cryoprobe tip from the frozen tissue [1044].

Liquid nitrogen-based cryoprobes provide the lowest temperature of the probe tip (-196°C that could be lower down to -209°C if supercooling of liquid nitrogen is used [854]). They have, however, two drawbacks. First, the diameter of the cryoprobe, due to a rather complex construction providing the efficient two-way flow of nitrogen, could not be made smaller than approximately 3 mm that limit the number of probes that can be used simultaneously (usually 5–6). A small number of cryoprobes forces operator to reposition cryoprobes during the operation to create a composite volume of overlapping spheres (ellipsoids) of frozen tissue. Second, liquid nitrogen systems react slowly to the changes in user input. An experimentally determined time delay is about 1–2 min [854]. In addition, transfer tubes and their associated valves should be precooled before operation; the cryoprobes for the short operations that have a small storage Dewar incorporated onto the probe itself are free of this minor disadvantage [723].

Modern cryoprobes using the Joule–Thomson effect – a constant enthalpy expansion of gas rapidly cooling it down to the boiling point – have a significantly smaller diameter. The modern systems based on the ultra-thin gauge needles (down to 1.47 mm diameter) allow direct transperinal insertion and, if necessary, relatively easy reposition of probes during the operation, reducing the disturbances of the tissues. The large number of cryoprobes used simultaneously (up to 17 [672]) provides the more flexible control of the shape and extension of the freezing zone, allowing treatment of irregularly shaped tumors. Additional flexibility of the treatment results from the ability of independent modulation in time of each of the multiple simultaneously operated cryoprobes.

Since some gases such as helium under the Joule–Thompson effect warm up rather than cool when expanded, it is possible to create systems for both cooling and heating with the rapid conversion between regimes. The gas cryoprobes using argon and helium can be modulated between -186°C and $+40$°C in about 30 s [854]. Different mixtures of hydrocarbons and synthetic

refrigerants with argon and nitrogen are also considered as potential working fluids [330, 708].

Liu et al. [576, 1124] developed on the novel minimally invasive probe system capable of performing both cryosurgery and hypertermia. In contrast to the systems using the Joule–Thompson effect, in the new system one can alternatively supply the cryoprobe tip with either liquid nitrogen or hot water vapor. The drawback of the system described by the authors is a rather high diameter of the probe (5 mm) needed to provide transport of a large amount of the working fluid.

Rabin and Shitzer [793] have modified the conventional cryoprobe by adding an electric heater to develop the computer-controlled system that provide such temperature of the probe that a specified constant cooling rate at the crystallization front is maintained.

Another advance of modern cryosurgery systems is the simultaneous use of a warming catheter ("cryoheater") to protect important organs in the close vicinity to the frozen malignant tissues such as the urethral mucosa.

A special cryoprobe for the study of early stages of osteonecrosis by introducing cryo insult in animal models that mimics naturally occurring osteonecrosis lesions was design by Reed et al. [818], which in contrast to practically all commercial cryoprobes based on the "passive" vacuum tube insulation incorporates "active" resistive electric heating that emulate insulation, giving two independent operator-controlled parameters: the mass flow rate of liquid nitrogen and the heating coil current.

In the early years of cryosurgery monitoring was essentially reduced to the temperature measurement, and a platinum resistance thermometer designed by Pegg and Hayes [748] for the temperature range from 37°C down to −200°C with an accuracy of 0.1°C was an essential achievement. Now cryosurgeon could use a number of advanced techniques such as US and NMR imaging.

Evidently, however, the progress in the development of the cryosurgery systems and the operation cooling/thawing protocols could neither diminish the crucial role of the surgeon nor liberate she/he from the responsibility for the treatment. New cryosurgical tools along with modern intraoperative monitoring techniques and mathematical modeling (preferably using the patient-specific anatomical data) just help the surgeon to make right decisions.

A.2 Low Temperature Preservation

The first studies in low temperature preservation were motivated by the development of artificial insemination (AI) procedures. Beginning of AI is attributed to Arabs stealing stallion semen from a rival tribe [212]. Horses also were the subject of the modern development of AI started by Ivanov in Russia in the beginning of twentieth century [661]. He studied AI in other domestic animals (dogs, rabbits, poultry) as well. Ishikawa, working with Ivanov, began a similar program in horses after returning to Japan in 1912 [322]. At

the same time, work on AI in horses was done in Denmark, at The Royal Veterinary College in Copenhagen, by Eduard Sorensen, who also was familiar with Ivanov's work. Sorensen is also known for his invention of straw for packaging semen [322].

In 1938, Jahnel reported the survival of human spermatozoa stored at the temperature of solid carbon dioxide. The systematic use of the frozen-thawed semen techniques was pioneered by Christopher Polge in the late 1940s, who worked with chicken and bull semen [212]. The early preservation procedures were developed in ad hoc manner and consist, for example, in the preliminary keeping the semen in glycerol for a very long time (glycerol equilibration time) or dilution in the sucrose–egg yolk mixture and vapor freezing as pellets.

Sperm motility was, and essentially remains, the main criterion to assess the success of the freezing procedure. Polge was the first to show that too large concentration of glycerol in the liquid semen decreases the fertility by the damage of the sperm cell membrane [119]. The first mammal – a calf – was produced with the cryopreserved spermatozoon in 1951 [558]; the first pregnancy obtained with the frozen stallion semen was reported by Barker and Gandlier in 1957 [68].

First experiments on the cryopreservation of human spermatozoa were reported in 1940 by Shelters (see [548]), who used direct plunging of thin-walled capillars with undiluted semen into alcohol cooled down to $-79°C$ with solid carbon dioxide, into liquid nitrogen at $-196°C$ or into liquid helium at $-269°C$. First pregnancy from a cryopreserved human embryo was reported in 1983 [1003].

A significant progress was achieved by Lovelock and Bishop by discovering the cryoprotective properties of dimethylsulfoxide in 1959 [589].

Probably the most important biological object subjected to low temperature preservation is the human erythrocyte – red blood cell. There are different reasons for the RBC transfusions – large RBC loss (traumatic or surgical hemorrhage), decreased bone marrow production, defective hemoglobin, and reduced RBC survival (hemolytic anemias). Low temperature preservation of RBC ex vivo for clinical use allows to separate the donor and the patient in space and time. Two obstacles to successful transfusion are blood clotting and in vitro loss of RBC viability and function. To overcome them, citrate as an anticoagulant was introduced by Hustin in 1914 and glucose as a preservative by Rous and Tumer in 1916; cryopreservation of RBC was pioneered by Smith and Lovelock in the early 1950s [880]. Later both vitrification and lyophilization also have been considered as the preservation approaches for RBC; the latter having evident advantages due to the stability of the dried cells at room temperature for the long time periods.

Advances in modern cryopreservation procedures could be divided into two directions:

- Optimization of the cooling/thawing protocols, including vitrification-based approaches and development of special procedures
- Improvement of the cryoprotective solutions

There is a number of special carriers or vessels developed for the CP, such as the open pulled straws (OPS), the flexipet-denuding pipette (FDP), microdrops, hemistraw systems, cryoloop and others [722].

A.2.1 CP Procedures

In total, seven vitrification-based procedures used for the conservation of genetic resources could be distinguished [296]:

1. Encapsulation–dehydration – cells are encapsulated in alginate beads kept for several days in the concentrated sucrose solution [47, 621, 820]; encapsulation–dehydration could be used with two-step cooling method [1119]
2. Vitrification – dehydration of sample with highly concentrated vitrification solution and subsequent rapid freezing
3. Encapsulation–vitrification – alginate beads are preliminary dehydrated at 0°C before plunging in liquid nitrogen [620]
4. Pregrowth – cultivation of samples in the presence of cryoprotectant, then direct immersion in liquid nitrogen
5. Pregrowth–desiccation – dehydration of the samples pregrown in the presence of CPA under the airflow cabinet or with silica gel, then rapid freezing [274]
6. Desiccation – probably the simplest procedure – direct immersion of the dehydrated samples into liquid nitrogen; sometimes the ultra-rapid drying in a stream of compressed dry air is performed [296]
7. Droplet freezing – small drops of the solution with samples placed on aluminum foil and frozen by direct immersion in liquid nitrogen.

Classical cryopreservation involves slow cooling down to a given prefreezing temperature, followed by rapid immersion in liquid nitrogen. In vitrification-based procedures, cell dehydration is achieved before freezing by exposure of samples to concentrated CPA solutions and/or by air desiccation and the subsequent rapid cooling. The critical stage in the classical approach is the freezing step and in vitrification it is the dehydration step. Vitrification has economic advantages, since it is relatively simple, it does not require the expensive programable freezing equipment and is very fast (this procedure requires several seconds).

A multistep freezing process consists, as a rule, of initial slow freezing followed by fast freezing to reach the final low temperature. Such procedure provides preliminary dehydration of tissues or organs that is beneficial in two aspects:

1. It minimize the amount of ice that can grow within organ capillaries, reducing the risk of injury due to the ice expansion within these vessels – such damage is a known problem in cryosurgery [840]
2. It increases the concentration of the CPA within cells

Multistep freezing is also preferable with respect to the development of the thermal stresses that may cause fracture in the tissues [898].

A specific method of the oocyte and embryo cryoconservation was reported by Nagashima et al. [697, 698], which consists of the preliminary stage of the polarization and removal of cytoplasmic lipids from the cells before vitrification. The authors thus avoided a negative aftereffect caused by the cooled intracellular lipids. While the intracellular lipids are considered as an energy source for oocytes and as building material for membranes of future embryos, their removal did not adversely affect the development of oocytes and embryos after cryopreservation [562].

The success of cryopreservation depends on the ability to control, in addition to the cooling rate, the nucleation temperature T_{n} [1001,1114]. T_{n} depends on the sample volume, properties of the container wall, and composition of the solution. T_{n} is also found to coincide with the onset of the liquid crystalline to gel phase transition in the cell membranes [1076]. Addition to the solution (similar to the approach developed in the freeze-tolerant animals) of ice nucleating substances such as *Pseudomonas Syringae* bacterium [1064, 1110] or nucleator, known for over half a century, silver iodide AgI [1037] shifts T_{n} to higher temperature but does not allow its precise control. In practice, initiation of crystallization (*seeding*) is achieved manually by touching the sample with cold tweezers or a cold rod. Some years ago, Petersen et al. described a device for controlling the nucleation temperature with a high accuracy for the cryopreservation system containing up to eight samples [757]. The action of the device is based on electrofreezing – an ability of high voltage applied to metal electrodes to cause nucleation in supercooled water, as was demonstrated for the first time by Rau in 1951 [755]. Petersen and collegues studied the influence of common cryobiology additives such as glucose, hydroxyethylstarch, glycerol on this effect and showed that it is also observed in the solutions of nonionic additives. However, the presence of ionic NaCl makes electrofreezing in solutions with physiological salt concentration impossible. This problem was solved by the authors by designing a separate volume of pure water inside the cap of platinum electrode that makes nucleus formation to be independent of the solution composition. It should be noted that cryopreservation is not the only field to benefit from the precise control of nucleation temperature – this parameter is known to strongly affect the rate of lyophillization [881].

Liquid nitrogen could be exposed to either atmospheric pressure or vacuum. The latter decreases the temperature by several degrees of centigrade (at 300 mm Hg pressure) down to -200°C. This improvement in CP was shown to significantly increase the development rate of bovine oocytes after vitrification [863].

For a long time all attempts at fish embryo conservation have failed. Only in 2007, Robles et al. [829] have reported some success in cryopreservation of two-cell embryos of seabream *Sparus aurata*, using the technique of microinjection of CPA into the embryo to overcome the permeability barrier [442]. The results also support the hypothesis that AFP (the authors used

a natural antifreeze protein type I), in addition to inhibition of ice growth and recrystallization, stabilizes the cellular membrane [829].

There are three ways to increase cooling rates [722] viz.:

1. To minimize the volume of the solution surrounding the cells
2. To minimize the thermo-insulation
3. To avoid liquid nitrogen vapor formation

The simplest way to minimize the thermo-insulation is to remove it by dropping the sample directly into the liquid nitrogen. However, this approach has a number of disadvantages. To form a drop, a rather large amount of the solution is needed. The drop will float for a long period of time on the surface of the liquid nitrogen. A strong evaporation on the surface will form a "vapor coat" as a thermo-insulated layer [452]. One of the approaches to solve this problem is to drop the solution containing sample cells onto the precooled metal plate (solid surface vitrification) [849].

It is known for a long time that the ice nucleation temperature can be reduced by an increase of the hydrostatic pressure [465], while the glass transition temperature rises with increased pressure [606]. This approach to the reduction of the needed CPA concentration is, however, limited, since high pressure can cause damage to the biological objects. For example, while dogs kidneys survive a 20-min exposure to 1,000 atm, rabitt kidneys were severely damaged after 20 min at 500 atm [722]. It should be note that high pressure is necessary for vitrification only – atmospheric pressure is sufficient for the storage.

Recently, a device for ultra-fast cooling has been suggested by A. Jiao et al. [452] based on the oscillating motion heat pipe (OHP) [453] that provide the extremely high heat exchange coefficient using the thin film evaporation effect in the oscillation motion of the liquid plugs and vapor bubbles. The authors state that the heat transfer coefficient over $10^4\,\mathrm{W\,m^{-2}\,K^{-1}}$ could be reached, which will provide, at least for some cooling methods such as ultra-thin straw (100 µm in diameter), cooling rates exceeding $2 \times 10^4\,\mathrm{K\,min^{-1}}$ that allows fivefold reduction of the passage time through the dangerous temperature region (DTR), typically from 240 to 200 K where most ice nucleation occurs, in comparison with conventional cooling techniques and thus significantly reduce the concentration (and, hence, toxicity) of the CPA solutions.

A special procedure has been developed for the CP of blastocysts that contain a fluid-filled cavity called the blastocoele. Since the probability of ice formation is proportional to the sample volume, this cavity is considered a weak point for the CP. In addition, CPA permeation into the blastocoele is slow: the resulting CPA concentration is insufficient after 3-min exposure of blastocysts to EG solution [722]. Vanderzwalmen et al. showed that survival rate could be improved by artificial reduction of the blastocoele with a needle or pipette before vitrification [1020].

A.2.2 CPA solutions

As a rule, there is no distinct difference between cryoprotective solutions for the hypothermic preservation and cryopreservation. Usually any hypothermic preservation solution as well as a buffered physiological solution could be used for cryopreservation [839]. Still, there are exceptions: for example, the so-called St. Thomas Hospital solution for the heart preservation is not good as a long storage medium [839].

Different additive are aimed at reducing the detrimental effects that accompanies cooling and freezing. Some solutions have been developed specially for the preservation of a particular organ. For example, UW solution (see below) was developed first for the liver preservation while the original Collins solution for kidney preservation. The latter tries to mimic the intracellular composition and is rich in K^+. Cardioplegic solutions differ in the basic ionic composition, which can be either intracellular (rich in K^+) or extracellular (rich in Na^+).

Sometimes different solution is used at the preliminary stages of CP: for example, spermatozoa are incubated in the cholesterol-loaded cyclodextrin, since loss of the cholesterol from the plasma membrane is one of the reasons of its destabilization [558].

A number of CPA mixtures has been suggested aiming primarily at the reduction of the solution toxicity: a low ionic-strength vehicle solution (LSV) containing propanediol and trehalose [1085], Euro-Collins solution [982], Hank balanced salt solution (HBSS), histidine–lactobionate (HL) solution [965], histidine–tryptophan–ketoglutanate (HTK) solution, sodium–lactobionate–sucrose (SLS) solution [994], to name a few [814].

Sometimes other components called extenders as citrates or egg yolk are added to CPA solution; these compounds are thought to have an additional protective effect during freezing and thawing [722]. The addition of polymers with high molecular weight such as polyvinylpyrrolidone (PVP) or polyethylene glycol (PEG) is aimed at assisting virtification, primarily the extracellular one, since cells contain large number of macromolecules similar in action.

The variety of the cryoconservation procedures and even greater variety of cryoprotective solutions sometimes is rightfully considered as an obstacle to the development of this technique since, in the absence of the evident best approaches, it disperse the research efforts instead of focusing on perfecting a single approach [722].

A milestone in the development of cryoprotective solutions is the invention in 1986 by Belzer and Southard from the University of Wisconsin of Madison, the synthetic solution called UW-solution [1042] that later became the practical standard in cryopreservation – it is usually a starting solution when a new preservation protocol should be developed [839]. The solution contains potassium lactbionate, adenosine, glutamine, allopurinol, hydroxyethyl starch, dexamethasone, and insulin [1042]. The comparative study proving its preference over other solutions was reported 2 years later [441]. It was also

found that the solution still could be improved by addition of natural factors (small proteins called trophic factors) increasing the storage time, and decreasing the organ damage by stimulation of DNA repair [390]. The recent natural components used in the storage solution are green tea polyphenolic compounds (GTPC) [64]. GTPC could act as biological antioxidant and protect mammalian cells and tissues from oxidative stress-induced damage [390].

Recent study by Wusterman et al. have shown that a significant reduction of the CPA solution toxicity could be attained by replacing sodium in the vehicle solution with choline [1084]. In the experiments, twofold and fourfold decrease of the fraction of cells losing their functional capacity were found for the porcine endothelial cells and muscle cells in suspension, respectively. As the authors state, the molecular mechanism by which sodium leads to cell death is still unclear, but it is probably mediated by hydrogen peroxide or nitride oxide. This opinion is supported by the earlier studies of the sodium effects in cardiomyocytes [773, 1095], hepatocytes [759], and fibroblasts [459]. The advantage of choline chloride over sodium chloride is believed to be its extracellular character with the similar colligative properties that prevents the damaging increase in the intracellular sodium concentration during cryoconservation using the conventional solutions. Beneficial choline properties were also reported for cryopreservation of oocytes [931] and embryos [999].

In spite of the great progress on cryopreservation and its role in the assisted reproduction (now it is possible, for example, to separate in the course of preservation X- and Y-bearing spermatozoa, thus allowing selective fertilization of oocytes to produce either female or male offspring), there are many unanswered question such as variability of the reaction of spermatozoa from different men to the same cryopreservation procedure or why the fraction of the sperm cells being damaged by freezing is about one half regardless of other conditions [548].

Cryopreservation is the cornerstone of the rapidly developing branch of medicine – regenerative medicine. Of particular importance is the ability to preserve engineered tissues such as veins, arteries, cartilage and, in perspective, even whole laboratory-produced organs to provide the needed supply for transplantation and allow the necessary gap in time between the moment a replacement is created and its final transplantation [308] . Another fascinating issue is the cryopreservation of human embryonic stem cells that could be lately used for regeneration of certain tissue or given back to the donor to correct age-related deficits (sometimes this emerging discipline is referred to as rejuvenatory medicine).

The difficulties of the whole organ cryopreservation, as was already mentioned, are primarily the different nature of the cells that constitute the organ (and, hence, different optimal preservation procedures) and the significant size that prevents the attaining of the spatial uniformity in both the temperature distribution and tissues saturation with CPAs.

Some progress was reported, but up to 2005 no vital organ (particularly heart or liver) has been deeply frozen to the low enough temperature needed

for the long-term storage and later thawed, transplanted, and proved to be functionally consistent [308]. One of the major reasons of failure is the vascular damage due to the mechanical action of ice crystals on the vascular wall. Thus vitrification seems to be the only promising way for the whole organ cryopreservation. Since ultrarapid cooling for large samples is evidently physically impossible, use of highly concentrated vitrification solutions that provide extreme increase of viscosity is inevitable. Recent review of the progress in vitrification of organ can be found in the cited paper by Fahy et al. [308].

B

Simulation of Solidification

> The absence of alternatives
> clears the mind marvelously.
>
> *H. Kissenger*

Unfortunately, there is no silver bullet – the single best numerical approach to the study of solidification process. The researcher is forced to make a choice of both the problem formulation and of the numerical method.

Solidification is the phase transition of the first order that involves energy release due to the self-organization of the solid phase – the latent heat of fusion. The boundary between phases that usually extends several molecular layers [228] (liquid near the interface could contain small crystallites [130] and the solid could have a rough surface) could be considered as either a sharp interface where a discontinuity in some of the system variables is present or as a thin transition layer where all thermodynamic parameters vary continuously. Sometimes these two approaches are referred to as the Gibbs approach and the van der Waals approach, respectively [88]. The former is surely more common, especially in the problems with the simple interface geometry.

In the general case, a number of constitutive equations of material are involved in the formulation of the solidification/melting problem. Beneś has listed these relations, subdividing them into those that relate to the bulk materials and those that relate to the interface between the phases:

1. Constitutive equations of material in the liquid (l) and solid (s) phases:
   - Bulk enthalpy per unit volume $H_{\mathrm{s}}(T)$, $H_{\mathrm{l}}(T)$
   - Bulk entropy per unit volume $S_{\mathrm{s}}(T)$, $S_{\mathrm{l}}(T)$
   - Bulk free energy per unit volume $F_{\mathrm{s}}(T) = H_{\mathrm{s}}(T) - TS_{\mathrm{s}}(T)$, $F_{\mathrm{l}}(T) = H_{\mathrm{l}}(T) - TS_{\mathrm{l}}(T)$
2. Constitutive equations for the interface:
   - Interfacial energy per unit area $e(T)$
   - Interfacial entropy per unit area $s(T)$
   - Interfacial free energy per unit area $f(T) = e(T) - Ts(T)$

The latent heat per unit volume is defined as $L = H_\mathrm{l}(T^\star) - H_\mathrm{s}(T^\star)$, where the transition temperature $T^\star$ is defined as the temperature at which the free energies of the phases are equal $F_\mathrm{l}(T^\star) = F_\mathrm{s}(T^\star)$.

B.1 Sharp Interface Methods

The Stefan problem is formulated for the sharp interface approach for the domain Ω by subdividing it by the (unknown) interface Γ into two subdomains – liquid Ω_l and solid Ω_s, so that $\Omega = \Omega_\mathrm{l} \cup \Omega_\mathrm{s} \cup \Gamma$ and could be stated as follows [88]. The heat conduction equation is to be solved in both the domains:

$$\frac{\partial H_\mathrm{l}}{\partial t} = -\nabla \mathbf{q}_\mathrm{l} \qquad \text{in} \qquad \Omega_\mathrm{l}(t), \tag{B.1}$$

$$\mathbf{q}_\mathrm{l} = -\lambda_\mathrm{l}(T)\nabla T, \tag{B.2}$$

$$\frac{\partial H_\mathrm{s}}{\partial t} = -\nabla \mathbf{q}_\mathrm{s} \qquad \text{in} \qquad \Omega_\mathrm{s}(t), \tag{B.3}$$

$$\mathbf{q}_\mathrm{s} = -\lambda_\mathrm{s}(T)\nabla T. \tag{B.4}$$

Here λ is the thermal conductivity and $\mathbf{q}$ is the heat flux.

The following conditions should be satisfied at the interface Γ:

$$T = \frac{H_\mathrm{l}|_\mathrm{l} - H_\mathrm{s}|_\mathrm{s} - k_\Gamma e}{S_\mathrm{l}|_\mathrm{l} - S_\mathrm{s}|_\mathrm{s} - k_\Gamma s}, \tag{B.5}$$

$$(\mathbf{q}_\mathrm{l} - \mathbf{q}_\mathrm{s})n_\Gamma = v_\Gamma(H_\mathrm{l}|_\mathrm{l} - H_\mathrm{s}|_\mathrm{s}) - k_\Gamma - D_t e, \tag{B.6}$$

where $\mathbf{n}_\Gamma$ is a unit vector to $\Gamma(t)$ pointing out of Ω_s, v_Γ is the normal velocity of the interface, D_t is the derivative with respect to time at $\Gamma(t)$, and $k_\Gamma = \nabla \cdot \mathbf{n}_\Gamma$ is the mean curvature of the hypersurface $\Gamma(t)$.

Under an assumption that the enthalpy in the solid and liquid phases is defined as

$$H_\mathrm{s} = \int_0^T \rho_\mathrm{s}(u)c_\mathrm{s}(u)\,\mathrm{d}u, \qquad H_\mathrm{l} = \int_0^T \rho_\mathrm{l}(u)c_\mathrm{l}(u)\,\mathrm{d}u + L,$$

where $\rho(T)$ and $c(T)$ are the density and the heat capacity of the corresponding phases of the material and denoting the difference in entropy per unit volume as $\Delta s = S_\mathrm{l}|_\mathrm{l} - S_\mathrm{s}|_\mathrm{s}$, the general formulation of the Stefan problem could be simplified to [88]

$$\rho(T)c(T)\frac{\partial T}{\partial t} = \nabla \cdot (\lambda(T)\nabla T) \qquad \text{in} \qquad \Omega_\mathrm{l} \quad \text{and} \quad \Omega_\mathrm{s}, \tag{B.7}$$

$$\lambda_\mathrm{s}(T)\frac{\partial T}{\partial n_\Gamma}\Big|_\mathrm{s} - \lambda_\mathrm{l}(T)\frac{\partial T}{\partial n_\Gamma}\Big|_\mathrm{l} = Lv_\Gamma, \tag{B.8}$$

$$T - T^\star = -\frac{\sigma(T)}{\Delta s}k_\Gamma - \alpha\frac{\sigma(T)}{\Delta s}v_\Gamma. \tag{B.9}$$

Here σ is the surface tension between the liquid and solid phases and α is the coefficient of the attachment kinetics.

The difference of the temperature at the interface and the transition temperature is usually referred to as kinetic undercooling or the Gibbs–Thomson effect. At the external boundaries of the computational domain, either Dirichlet boundary conditions for the temperature or the Neumann boundary conditions for the heat flux are specified.

The most specific feature of the Stefan problem is the unknown boundary between the liquid and solid domains – crystallization front. Sometimes other moving boundary problems are referred to as Stefan problems. Lame and Clapeyron were the first to consider such problems in 1831; these problems, however, were named after Stefan, who more than half a century later studied the melting of the polar ice cap [418].

On the Stefan problems where the convection in fluid is important, please see [152] for the Newtonian fluid and [706] for the case of more general rheology.

Most of the numerical methods used to solve the Stephan problem are divided into two-domain (three-domain in the case of the explicit treatment of the mushy zone) or front tracking methods in which the interface movement is monitored explicitly, and single-domain (one-domain) methods in which the interface position could be reconstructed as a post-processing procedure. The classification is self-evident; similar division of methods used in the simulation of the gas flows with shock waves using Euler equations for the inviscid fluid, the second group being usually called front-capturing method. Somewhat aside particle and cellular automata methods stand. Numerical methods for tracking discontinuous fronts and interfaces could be subdivided into several groups [424].

In *surface tracking* methods, the interface is identified by a set of marker points, between which the interface position is approximated by an interpolant. The solution along the interface may be multivalued to account for the discontinuities. The evolution of the interface is usually governed by the differential equations of the lower dimensionality that are derived, as a rule, by the application of Gauss–Ostrogradskii type theorem to the constitutive equations, using the local curvilinear coordinate system orthogonal to the interface. The implementation of these methods consist of two distinct stages: interface updating and interface smoothing. The common problem of the methods of this class is the sensitivity of the interface to the numerical noise.

Volume tracking methods are best for the description of the interaction of the relatively smooth moving interfaces. The interface tracking equations have the same dimensionality as the underlying PDE of the model; however, they need to be solved in the narrow strip containing the interface. The best known member of this family of methods is the famous MAC (marker and cell) method developed over 40 years ago by Harlow and colleagues, another one is the volume of fluid (VOF) method based on monitoring of fraction of each material in every computational cell.

Moving mesh methods include local adjustment methods or Langrangian methods; one of the most flexible variant of the latter is the so-called arbitrary Lagrangian Eulerian (ALE) method that combines advantages of these two approaches to the description of the moving media.

B.1.1 The Classical Stefan Problem

The classical Stefan problem deals with solidification or melting in the so-called pure substances. Pure substance is an idealization allowing one to disregard diffusion processes – solidification is driven by the temperature evolution alone. Thermomechanical properties are assumed to be constant.

In the absence of fluid convection in both Ω_l and Ω_s subdomains, heat conduction equation is to be solved:

$$\rho c \frac{\partial T}{\partial t} = \lambda \Delta T,$$

coupled by the condition on the interface (sometimes called the Stefan condition) that expresses the continuity of the heat flux, with account for the surface heat source or sink at the interface due to crystallization or melting, value for which is the product of the normal component of the interface velocity v_γ and the latent heat L of the phase transition [88]:

$$\lambda_\mathrm{s} \frac{\partial T}{\partial n_\Gamma}\Big|_\mathrm{s} - \lambda_\mathrm{l} \frac{\partial T}{\partial n_\Gamma}\Big|_\mathrm{l} = L v_\Gamma, \tag{B.10}$$

where T is the temperature, ρ is the density, c is the heat capacity, λ is the thermal conductivity, and $\mathbf{n}_\Gamma$ is the outer normal to the solid subdomain.

B.1.2 Exact solutions

Some analytical solutions have been obtained for the one-dimensional Stefan problem in different coordinate systems. Stefan had obtained an analytic solution to the so-called one-phase problem, assuming the thermal parameters to be constant, and showed that the rate of solidification or melting in the semi-infinite region is governed by a dimensionless parameter

$$\mathrm{St} = \frac{C_\mathrm{l}(T_1 - T_\mathrm{m})}{L},$$

which later was named Stefan number. Here C_l is the heat capacity of the liquid, L is the latent heat of fusion, T_1 is the temperature of the surrounding media, and T_m is the melting temperature.

Plane Solidification

John von Neumann obtained a solution to a more realistic two-phase problem. The melting of the semi-infinite region ($0 < x < \infty$) under the uniform initial

temperature $T_s \leq T_m$ is considered. The constant temperature is imposed at the boundary $x = 0$, and the thermal properties are assumed to be constant. The following equations constitute the problem formulation:

Heat conduction in the liquid region ($0 < x < X(t),\ t > 0$):

$$\frac{\partial T_l}{\partial t} = \alpha_l \frac{\partial^2 T_l}{\partial x^2}.$$

Heat transfer in the solid region ($X(t) < x,\ t > 0$):

$$\frac{\partial T_s}{\partial t} = \alpha_s \frac{\partial^2 T_s}{\partial x^2}.$$

The temperature at the interface:

$$T(X(t), t) = T_m.$$

Stefan condition (a balance of the heat fluxes):

$$\kappa_s \frac{\partial T_s}{\partial x} - \kappa_l \frac{\partial T_l}{\partial x} = L\rho \frac{\mathrm{d}X}{\mathrm{d}x}.$$

To close the system initial

$$T(x, 0) = T_s < T_m$$

and boundary conditions

$$\begin{aligned} &T(0, t) = T_l > T_m, \\ &T(x, t) = T_s \qquad \text{for} \qquad x \to \infty, t > 0 \end{aligned}$$

are specified.

von Neumann using the similarity variable $\eta = x/2\sqrt{\alpha_l}$ had obtained an analytical solution that is expressed as follows [418] (erf and erfc are the error function and the complimentary error functions, respectively):

Position of the interface between the solid and liquid domains

$$X(t) = 2\lambda\sqrt{\alpha_l t}.$$

The temperature in the liquid phase

$$T(x, t) = T_l - (T_l - T_m)\frac{\mathrm{erf}(x/2\sqrt{\alpha_l t})}{\mathrm{erf}(\lambda)}.$$

The temperature in the solid phase

$$T(x, t) = T_s + -(T_m - T_s)\frac{\mathrm{erfc}(x/2\sqrt{\alpha_s t})}{\mathrm{erfc}(\lambda\sqrt{\alpha_l/\alpha_s})}.$$

The parameter λ is determined from the equation

$$\frac{\mathrm{St}_l}{\exp(\lambda^2)\mathrm{erf}(\lambda)} - \frac{\mathrm{St}_s\sqrt{\alpha_s}}{\sqrt{\alpha_l}\,\exp(\alpha_l\lambda^2/\alpha_s)\mathrm{erfc}(\lambda\sqrt{\alpha_l/\alpha_s})} = \lambda\sqrt{\pi},$$

where

$$\mathrm{St}_l = \frac{C_l(T_l - T_m)}{L}, \qquad \mathrm{St}_s = \frac{C_s(T_m - T_s)}{L}.$$

Cylindrical Solidification

Paterson in 1952 had obtained a similar solution for the case of the cylindrical coordinates. A line heat source of strength Q is located at the symmetry axis of the infinite solid body held under the temperature $T_\mathrm{s} < T_\mathrm{m}$. The heat source is activated at time $t = 0$. The energy balance near the heat source could be written as

$$\lim_{r\to 0}\left[-2\pi\kappa_\mathrm{l}\frac{\partial T_\mathrm{l}}{\partial r}\right] = Q\ .$$

The Paterson solution is expressed as follows [418]:

Position of the interface

$$R(t) = 2\lambda\sqrt{\alpha_\mathrm{s} t}.$$

The temperature in the liquid phase

$$T(r,t) = T_\mathrm{s} + \frac{T_\mathrm{m} - T_\mathrm{s}}{\mathrm{Ei}(-\lambda^2\alpha_\mathrm{s}/\alpha_\mathrm{l})}\ \mathrm{Ei}\left(-\frac{r^2}{4\alpha_\mathrm{s} t}\right).$$

The temperature in the solid phase

$$T(r,t) = T_\mathrm{m} - \frac{Q}{4\pi\kappa_\mathrm{s}}\left[\mathrm{Ei}\left(-\frac{r^2}{4\alpha_\mathrm{s} t}\right) - \mathrm{Ei}(\lambda^2)\right].$$

The parameter λ is determined from the equation

$$-\frac{Q}{4\pi}\,\mathrm{e}^{-\lambda^2} + \frac{\kappa_\mathrm{l}(T_\mathrm{m} - T_\mathrm{s})}{\mathrm{Ei}(-\lambda^2\alpha_\mathrm{s}/\alpha_\mathrm{l})}\,\mathrm{e}^{-\lambda^2\alpha_\mathrm{s}/\alpha_\mathrm{l}} = \lambda^2\alpha_\mathrm{s}\rho L,$$

where $\mathrm{Ei}(x)$ is the exponential integral function:

$$\mathrm{Ei}(x) = \int_{-x}^{\infty}\frac{\mathrm{e}^{-t}}{t}\,\mathrm{d}t.$$

Freezing of Porous Media

The case of crystallization with the explicitly described mushy zone – an extension of the von Neumann solution – was obtained by Lunardini in 1985 (see [648]), who studied the freezing of the porous media. The solution is written as follows (indices 1, 2, and 3 refer to the solid, mushy, and liquid zones, respectively):

$$T_1 = (T_\mathrm{m} - T_\mathrm{s})\frac{\mathrm{erf}(x/2\sqrt{\alpha_1 t})}{\mathrm{erf}(\psi)} + T_\mathrm{s},$$

$$T_2 = (T_\mathrm{m} - T_\mathrm{f})\frac{\mathrm{erf}(x/2\sqrt{\alpha_4 t}) - \mathrm{erf}(\gamma)}{\mathrm{erf}(\gamma) - \mathrm{erf}(\psi\sqrt{\alpha_1/\alpha_4})} + T_\mathrm{s},$$

$$T_3 = (T_0 - T_\mathrm{f})\frac{-\mathrm{erfc}(x/2\sqrt{\alpha_3 t})}{\mathrm{erfc}(\gamma\sqrt{\alpha_4/\alpha_3})} + T_0,$$

where T_0 is the initial temperature, T_m and T_f are the solidus and liquidus temperatures, T_s is the boundary temperature, α_1 and α_3 are the thermal diffusivities of the regions 1 and 3, respectively, defined as

$$\alpha_1 = \frac{k_1}{C_1}, \qquad \alpha_3 = \frac{k_3}{C_3},$$

C_1 and C_3 are the volumetric heat capacities of these regions.

The thermal diffusivity of the mushy region is assumed to be constant with latent heat term included

$$\alpha_4 = \frac{k_2}{C_2 + \frac{\gamma_\mathrm{d} L \Delta\xi}{(T_\mathrm{f} - T_\mathrm{m})}},$$

where $\gamma_\mathrm{d} = (1-\varepsilon)\rho_\mathrm{s}$ is the dry unit density of the media solids, $\Delta\xi = \xi_0 - \xi_\mathrm{f}$, ξ_0 and ξ_f are the ratio of the unfrozen water to the media solid mass for the fully thawed and frozen states, respectively, given as

$$\xi_0 = \frac{\varepsilon\rho_\mathrm{w}}{(1-\varepsilon)\rho_\mathrm{s}}, \qquad \xi_\mathrm{f} = \frac{\varepsilon S_\mathrm{wres}\rho_\mathrm{w}}{(1-\varepsilon)\rho_\mathrm{s}}.$$

Here S_wres is the residual saturation.

The evolution in time of the position of the boundaries of the mushy and solid regions is given as

$$X_1(t) = 2\psi\sqrt{\alpha_1 t}$$

and

$$X(t) = 2\gamma\sqrt{\alpha_4 t}.$$

The parameters ψ and γ are defined by the following system of equations:

$$\frac{(T_\mathrm{m} - T_\mathrm{s})}{(T_\mathrm{m} - T_\mathrm{f})}\,\mathrm{e}^{\psi^2(1-\alpha_1/\alpha_4)} = \frac{k_2/k_1\sqrt{\alpha_1/\alpha_4}\,\mathrm{erf}(\psi)}{\mathrm{erf}(\gamma) - \mathrm{erf}(\psi\sqrt{\alpha_1/\alpha_4})},$$

$$\sqrt{\alpha_3/\alpha_4}\,\frac{(T_\mathrm{m} - T_\mathrm{f})k_2/k_3}{(T_0 - T_\mathrm{f})}\,\mathrm{e}^{\gamma^2(1-\alpha_4/\alpha_3)} = \frac{\mathrm{erf}(\gamma) - \mathrm{erf}(\sqrt{\alpha_1/\alpha_4}\psi)}{\mathrm{erfc}(\gamma\sqrt{\alpha_4/\alpha_3})}.$$

In the classical Stefan problem as well as in the majority of the simulation studies the densities of the liquid and solid phases are assumed to be equal. Generally, it is not so and the difference in density could be significant, for example, in water crystallization. Griebel et al. [372] considered this case. Conservation of mass across the phase boundary allows to equate the normal mass fluxes in both phases at the phase boundary to get

$$\mathbf{v}\cdot\mathbf{n} = \left(1 - \frac{\rho_\mathrm{s}}{\rho_\mathrm{l}}\right)\mathbf{V}_\Gamma\cdot\mathbf{n}\,,$$

where $\mathbf{v}$ is the velocity of the liquid phase and $\mathbf{V}_\Gamma$ is the crystallization front velocity.

The temperature at the interface is continuous $T_\mathrm{s} = T_\mathrm{l}$; to formulate the second condition, the authors considered the total energy balance across the interface that is expresses as

$$\left[\rho e(\mathbf{v} - \mathbf{V}_\Gamma) + \mathbf{q} \cdot \mathbf{n} - \mathbf{n}^\mathrm{T} \mathcal{P} \mathbf{n}\right]_\mathrm{s}^\mathrm{l} = -\gamma K \mathbf{V}_\Gamma \cdot \mathbf{n} \,,$$

where $e = u + \mathbf{v} \cdot \mathbf{v}/2$, the internal energy is defined in liquid and solid phases as $u_\mathrm{l} = c_\mathrm{l}(T - T_\mathrm{m})$ and $u_\mathrm{s} = c_\mathrm{s}(T - T_\mathrm{m}) - L$, respectively, and the term in the right hand side related to the interfacial energy originates from the Gibbs–Thompson effect, $\mathcal{P}$ is the stress tensor of the Navier–Stokes equations

$$\mathcal{P}^{ij} = -p\delta_{ij} + \mu \left(\frac{\partial v_i}{\partial x_j} + (\frac{\partial v_j}{\partial x_i} \right) + \lambda \nabla \mathbf{v} \delta_{ij} \,,$$

where μ and λ are viscosities. Details of derivation and the final relations could be found in the cited apper.

B.2 Diffuse Interface Methods

The van der Waals approach to the solidification was revived by Cahn and Hillard in the middle of the twentieth century and applied to problems where the microstructure of the forming solid is of interest, for example, for the study of spinodal decomposition. The best known implementation of this approach is the so-called phase field theory methods [367] for the solidification simulation. There are two other classes of problems where the diffuse interface approach seems to be preferable.

Crystal nucleation involves the formation of heterogeneous fluctuations containing crystal-like atomic arrangements. Those fluctuations grow whose size exceeds some critical value determined by the interplay of the interfacial and volumetric contributions to the free energy of the cluster that typically contains tens to hundreds atoms or molecules. As was mentioned in Sect. 3.2.2, the classical nucleation theory that assumes a sharp interface between the nucleated embryo and the mother media and uses bulk materials properties for the critical nucleus encounters difficulties in the case of small critical radius. Evidently, the sharp interface approach could hardly provide an adequate description of small clusters whose size is comparable to the physical interface thickness.

The other problem that is difficult to describe using the sharp interface approximation is the polycrystalline growth [368] that usually proceeds in one of the two main modes [367]:

- Impingement of independently nucleated single crystals (primary nucleation)
- Nucleation of the new crystalline grains at the perimeter of the existing particles (secondary nucleation)

The most advanced implementation of the diffuse (nonsharp) interface approach is the phase field theory based on introduction of the order parameters that define the local thermodynamic state of the material. The simplest case involves a single order parameter – phase field φ that monitors the interface between the liquid and the solid states. Other parameters (usually this model is referred to as vector-valued phase field model [504]) could be the chemical composition or the orientation field that specifies the orientation of the crystallographic planes of the growing crystal [367].

The thermodynamic functional $\mathcal{F}$ (frequently, the free energy) is expressed via the volumetric density that depends on a set of the order parameters $\varphi_1, \varphi_2, \ldots, \varphi_N$:

$$\mathcal{F} = \int_{\Omega} (w(\varphi_1, \varphi_2, \ldots, \varphi_N) + G(D\varphi_1, D\varphi_2, \ldots, D\varphi_N))\, \mathrm{d}x.$$

This functional includes contributions from the bulk density $w(...)$ and a gradient term G that accounts for the nonuniformity of the system. Frequently w is of the multiwell types and so there are some preferable states of the system.

The system evolution in time expressed as the functional relaxation to the minimum value is described by the so-called Model A equation [413]:

$$\tau_i \frac{\partial \varphi_i}{\partial t} = -\delta_{\varphi_i} \mathcal{F}[\varphi_1, \varphi_2, \ldots, \varphi_N],$$

where $\delta_{\varphi_i} \mathcal{F}$ is the Frechet derivative and τ_i is a relaxation parameter.

If the system state is described by single parameter, it could distinguish between liquid and solid or ordered and disordered states of the system. The equation for the evolution of the order parameter in case of crystallization is solved together with the energy equation that governs the heat transfer [367, 504].

The importance of the phase field theory methods is expected to increase in future due to both its ability to cope with complex interfaces encountered such as the branched dendrite structures that are difficult for the sharp interface treatment and possibilities provided by the progress in the computer hardware.

C

Thermal Properties of Tissues

Model-based optimization algorithms for the planning of the thermal treatment, both hyperthermia and cryosurgery, will give reliable predictions if the thermal properties of tissues are known with a sufficient accuracy. Unfortunately, these properties are poorly known, especially for temperatures below $-40°C$, and are often approximated by those of water [388].

The experimental methods to determine thermal properties of biological tissues are rather advanced for the case of homogeneous samples. The measurements of spatially varying properties are more involved, especially when simultaneously both the thermal conductivity and the heat capacity are to be determined [319,419,1107]. The additional difficulty of the measurement of the thermal properties of biological tissues in vivo is the need to estimate and separate the blood perfusion contribution to the heat transfer [830]. Finally, the measurement techniques should be noninvasive and be able to operate with small temperature differences acceptable for tissues. As a rule, one should solve the inverse problem and frequently exploit some model of heat transfer in the biological media [867, 973, 983].

Huttunen et al. recently reviewed approaches to the determination of heterogeneous thermal properties of biological tissue [423]. The authors themselves used ultrasound-induced heating to provide the necessary temperature gradients in tissues and MR imaging the temperature evolution. This technique was used earlier to measure the properties of homogeneous medium by Cheng and Plewes [181] and by Vanne and Hynynen [1021]. Huttunen and coworkers considered the target domain that contains several sub-domains in which the tissue parameters, both thermal and acoustic, can be assumed constant. Note that this approach could provide the temperature-independent properties only. To extract the thermal properties from the temperature measurements, the authors used the classical Pennes' equation, neglecting the metabolic heat source. The semi-discrete Galerkine FEM with piecewise linear basis functions were used.

The thermophysical properties of some specific tissue are known to depend on the number of factors such as age, gender, ethnicity, circadian rhytm, and state of thermoregulatory sweating [780]. The state of the blood vessels greatly affect the measured values of the tissue parameters. Thus, according to experiments performed by Parsons on the heat transfer in human skin, the thermal conductivity could vary from 0.2–0.3 $\mathrm{W\,m^{-1}\,K^{-1}}$ in the vasoconstricted state to 0.4–0.9 $\mathrm{W\,m^{-1}\,K^{-1}}$ in the vasodilated state [445, 780].

One approach to estimate the thermal properties of the biological tissues is the volume averaging that is frequently used for the heterogeneous media, such as, for example, soil [648]:

$$\lambda = \varepsilon S_{\mathrm{w}} \lambda_{\mathrm{w}} + \varepsilon S_{\mathrm{ice}} \lambda_{\mathrm{ice}} + (1 - \varepsilon) \lambda_{\mathrm{s}},$$

where ε is the porosity, λ_{w}, λ_{ice}, and λ_{s} are the thermal conductivities of liquid water, ice, and solid matrix, respectively, and S_{w} and S_{ice} are the saturation of liquid water and ice.

The averaging based on the mass fractions of water, proteins, and fats in the biological objects with different weights is common in both medicine and food industry; frequently the coefficients suggested many year ago by Cooper and Trezek [207] are used for thermal conductivity, specific heat, and density.

C.1 Human

Thermal properties of some human tissues are presented in Table C.1.

Table C.1. Properties of human tissues

Tissue	Density ($10^3\,\mathrm{kg\,m^{-3}}$)	Thermal conductivity ($\mathrm{W\,m^{-1}\,K^{-1}}$)	Specific heat ($10^3\,\mathrm{J\,kg^{-1}\,m^{-3}}$)	Reference
Skin, epidermis	1.2	0.21	3.6	[1066]
Skin, epidermis		0.21	4.32	[218]
Skin, dermis	1.2	0.53	3.8	[1066]
Skin, dermis		0.53	4.56	[218]
Fat	0.85	0.16	2.3	[1066]
Spleen		0.5394		[50]
Spleen	1.05	0.546		[59]
Muscle	1.05	0.642	3.75	[780]
Muscle	1.27	0.53	3.8	[1066]
Lung		0.4506		[50]
Bone, cancellous	1.7	0.582	1.59	[780]
Kidney	1.05	0.54	3.9	[962]
Kidney	1.05	0.546	3.74	[59]
Liver	1.06	0.57	3.6	[962]
Liver		0.5122		[50]
Liver	1.05	0.567		[59]

C.2 Animals

Dogs look up to us.
Cats look down on us.
Pigs treat us as equals.

Sir Winston Churchill

All animals are equal but some animals are more equal than others.

George Orwell

Sir Winston, The Fellow of the Royal Society, was right – in many respect pig is the closest to human animal and is preferred model compared to other organisms [690, 1007]. Animal models that are currently in use include non-human primates, rodents (rats, mice, guinea pigs), large animal models (pig, dog, sheep), the chick, and simple animals, including fish, insects, and round worms. Each model system has strengths and weaknesses, depending on the question being addressed.

Thermal conductivities of some animal tissues, adapted from the data by Holmes [1018], are presented in Table C.2.

Table C.2. Properties of animal tissues

Tissue	Animal	Thermal conductivity ($\mathrm{W\,m^{-1}\,K^{-1}}$)
Kidney, whole	Rabbit	0.502
Kidney, cortex	Rabbit	0.465
Kidney, cortex	Dog	0.491
Liver	Rabbit	0.493
Liver	Rat	0.498
Liver	Sheep	0.495
Liver	Dog	0.55
Muscle	Rat	0.505
Muscle	Pig	0.518
Muscle	Cow	0.410
Skin	Giraffe	0.442
Skin	Crocodile, back	0.432
Skin	Crocodile, tail	0.334

C.3 Latent heat

One more parameter characterizing biological solutions should be known to provide the reliability of numerical simulations – latent heat of the phase change that is frequently taken equal to that of pure water. Shepard et al. [894] were probably the first to study the phase change properties of the solutions relevant to cryobiology. Han et al., using DSC thermograms, measured the latent heat of different aqueous mixtures of biological relevance [189,388,389], including sodium chloride and phosphate-buffered saline solution with different chemical additives. The authors have considered glycerol and raffinose as examples of CPAs, and antifreeze protein (type III, molecular weight 6,500), and sodium chloride as a cryosurgical adjuvant. They found that latent heats do not correlate directly (i.e., in a linear fashion) with the water content, but could be correlated with the amount of water that participates in the phase change. The measurements gave the value 303.7 and $233.0\,\mathrm{J\,g^{-1}}$ for water–ice and eutectic phase change, respectively. The reason for the former being smaller than that for pure water ($335\,\mathrm{J\,g^{-1}}$) warrants further study. Latent heat of crystallization is found to sharply drop for large concentration of glycerol [189]. The authors also found the disappearance of the eutectic phase transition when even a small amount of glycerol was added, which again was observed after addition of AFP. The eutectic crystallization occurs only under a significant supercooling in contrast to the melting that is in good agreement with the phase diagram temperature.

Similar studies have been performed by Devereddy et al. [251] who base the analysis of the measurements, as the authors themself state, "on the full set of heat and mass transport equations." The authors wrote out (6.46) and (6.39) for the case of spherical crystals growing in the solution that are all assumed to be identical and grow independently in its own pool of liquid. In fact, only mass transfer equation is solved, since estimates of the similarity parameters showed that heat transfer occurs so rapidly that the temperature could be assumed uniform throughout the system. The authors suggested several explanations for the observed reduction of the latent heat in the considered aqueous solutions in comparison with pure water, including transformation of some amount of water into the unfreezable form due to binding to solutes and possible entropic effects due to the ordering of the water in the presence of solutes prior to the phase transition.

Glossary

Acclimation, acclimatization Physiological or behavioral changes occurring within the organism to reduce the strain caused by the environment alterations.

Adenosine triphosphat (ATP) Chemical participating in the various metabolic reactions.

Aerobic Conditions in which oxygen is present.

Albumin A protein with molecular weight ≈68,000 Da used to reduce the stickness of oocytes and embryos as well as in CPA solutions.

Amino acid Nitrogen containing carboxylic acid.

Amphibians Four-legged vertebrate that can breath water or air.

Anaerobic Conditions without oxygen.

Anapyrexia A pathological state in which there is a regulated decrease of the body temperature.

Annealing Holding a sample at a specific subzero temperature. Used in studies of the steady state ice nucleation and crystal structure.

Antifreeze protein (AFP) Macromolecule that inhibits ice growth usually having hydrophobic face which preferentially binds to crystalline ice and hydrophilic face which preferentially binds water.

Apoptosis Cell suicide – programed cell death.

Artificial insemination (AI) Placing sperm into the vagina or uterus using artificial means rather than by natural copulation. Nowadays, intrauterine insemination is only used.

ART Assisted Reproduction Technology. Procedures to bring about conception without sexual intercourse. ART procedures include IUI, DI, GIFT, ZIFT, ICSI, IVF.

ATP Adenosine triphosphate.

Bilayer Lipid bilayer consists of two layers of lipids with their hydrophobic ends toward each other and the hydrophilic ends opposite.

Blastocyst An advanced embryo, which when hatched, forms the trophectoderm which eventually forms the placenta and inner cell mass which forms the fetus.

Bradymetabolic see *Cold-blooded*

Buffer A component of the CPA solutions that is usually some common physiological buffer such as phosphate-buffered saline, choline, chloride-based buffer, serum.

Cancerous Unregulated growth in a multi-tissue organism.

Circadian Related to 24-h periodicity of a free running biological rhythm.

Chromosomes Structures that contain and organize a eukaryotic cell's DNA.

Cold-blooded Also poikilothermic, bradymetabolic. The thermal state of an animal in which the body temperature is close to the ambient temperature.

Cold shock Injury due to rapid drop in temperature.

Cold tolerance The ability to endure low ambient temperatures.

Chill injury Damage to cells that occurs at temperatures above zero.

Cholesterol A lipid found in the cell membranes of all animal tissues. Cholesterol is also a sterol (a combination steroid and alcohol).

Choline chloride A salt (molecular weight 139.6) used in some CPA solutions instead of sodium chloride.

Colligative Properties of a solution that are not present without the mixture and do not depend on the nature of the solute, just on its amount. Effects of colligative properties include lowering of vapor pressure, elevation of boiling point, depression of freezing point, and osmotic pressure.

Cryofixation Freezing a specimen so rapidly, to liquid nitrogen temperatures, that the water forms vitreous (noncrystalline) ice. This preserves the specimen in a snapshot of its solution state.

Cryoprotectant, cryoprotective agent (CPA) Chemical that reduces cell injury during freezing and thawing.

Cryoprotectant, nonpermeating CPA that does not cross the cell membrane (sugars, polymers, and proteins). These CPAs lower the freezing point, replace some of the water molecules around proteins and other cytosol components.

Cryoprotectant, permeating CPA that penetrate into the cell (DMSO, EG, glycerol, propylene glycol, and propanediol). These CPAs help cell dehydration, stabilize the cellular membrane.

Cryopreservation The process of cooling and storing cells, tissues, or organs at very low or freezing temperatures to save them for future use.

Cryosurgery Procedure in which tissue is frozen to destroy the malignant abnormal cells within an organism. This is usually done with a special instrument that contains liquid nitrogen or liquid carbon dioxide. Also called cryoablation.

Cuboidal (cubic) ice The metastable form of ice I_c. All atoms have four tetrahedrally arranged nearest neighbors and 12 second nearest neigbors.

Cytoplasm The intracellular fluid in which all organelles reside. Consists of water, ions, small organic molecules, proteins.

Cytoskeleton Structural component of eukaryotic cells comprised of microtubules, microfilaments, intermediate filaments that provide structural support for the cell.

Dehydration The removal of water from an object. In physiologic terms, it entails a relative deficiency of water molecules in relation to other dissolved solutes. In cryobiology reducing the water content of the cell that decrease the probability of damaging intracellular ice formation during cooling.

Dehydration curve A graph plotting water content of the cell vs. time in the CPA solution or vs. temperature during cooling.

Denaturation A change of the three-dimensional conformation of a protein.

Devitrification Transition from vitreous solid to crystalline state.

Differential scanning calorimetry (DSC) The measuring approach sensitive to small changes such as the release of heat during ice crystallization and the uptake of heat during melting.

Differentiation Process by which a cell converts from generic to specialized one that is capable of doing specific tasks.

Dimethylsulphoxide (DMSO) Mol. Wt. 78.13. A colorless liquid that readily dissolves many chemicals and penetrates animal and plant tissues. Cryoprotective agent, most frequently used for preservation of oocytes and embryos.

Donor insemination (DI or ADI) Artificial insemination with donor sperm.

Donor IVF (DIVF) In vitro fertilization using donor sperm.

Gamete Male or female sex cell (ovum or spermatozoon).

Gibbs free energy Measure of a work that can be extracted from the system at a constant pressure and temperature.

Glycerol Glycerine, also called 1,2,3-propanetriol. Low toxicity CPA used for sperm and blastocysts.

EFS Mixture of ethylene glycol, Ficoll, and sucrose used for the preservation of mammalian embryos.

Electroporation The creation of pores in the cell membrane, through the application of a high-voltage electrical pulse.

Electroporation, irreversible The creation of the permanent pores in the cell membrane, through the application of a high-voltage electrical pulse. Used for the tissue destruction.

Electroporation, reversible The creation of pores in the cell membrane that are later sealed, through the application of a high-voltage electrical pulse. Used for the drug delivery.

Embryo The early stage of fetal life starting at the fertilized egg or zygote through to blastocyst and eventually the fetus.

Embryo transfer Placement of an embryo into the uterus of a woman after it has been created in a laboratory.

Endothelium The thin layer of cells that line the interior surface of blood vessels, forming an interface between circulating blood in the lumen and the rest of the vessel wall.

Enzyme Protein that acts as a catalyst for a biochemical reaction.

Epithelium A tissue composed of layers of cells that line the cavities and surfaces of structures throughout the body.

Ethylene glycol (EG) Also called 1,2-ethanediol (Mol. Wt. 62.07). Used widely for the preservation of oocytes and embryos, frequently in combination with DMSO.

Eukaryotes Organisms that have a nucleus in their cells.

Eutectic mixture A mixture at such proportions that the melting point is as low as possible, and that furthermore all the constituents crystallize simultaneously at this temperature from solution.

Eutectic point Lowest temperature where liquid phase is in equilibrium with solid phase.

Exosmosis Movement of water out of cell by osmosis.

Exposition Also exposure time, holding time – length of time the sample is exposed to a given solution or a given temperature.

Fertilization The successful union of the sperm and egg.

Fibroblasts Cells that make extracellular matrix.

Freeze avoidance The ability of the living organism to prevent ice formation inside organism.

Freeze drying see *Lyofillization*

Freeze tolerance The ability of the living organism to endure ice formation inside organism.

Freezing-point depression Lowering of the freezing point of a solution when another compound is added so that a solution has a lower freezing point than a pure solvent.

Glass transition temperature The temperature at which vitrifying solutions change from/to solid, stable glass-like state.

GIFT: Gamete Intra Fallopian Transfer The combining of eggs and sperm outside of the body for fertilization and their immediate placement into the fallopian tubes to achieve fertilization and pregnancy.

Glucose Six carbon sugar.

Glycolipid Carbohydrate-attached lipid. Glycolipids role is to provide energy and also serve as markers for cellular recognition.

Heterogeneous nucleation The formation of ice nuclei with the help of foreign surface or particle.

Hexagonal ice The normal form of ice denoted as I_{h}. Protons are disordered, but molecules form hexameric box-like structures arranged as stacked sheets.

Homeostatis General term characterizing the relative constancy of the physico-chemical properties of an organism being maintained by regulation.

Homeothermic see *Warm-blooded*

Homogeneous nucleation The spontaneous formation of ice nuclei without assistance of foreign bodies.

Hydrophilic A polar molecule that is soluble in water.

Hydrophobic A nonpolar molecule that is insoluble in water.

Hyperthermia A state when the body temperature is above normal for the species in question; could be regulated or forced (induced).

Hypothermia A state when the body temperature is below normal for the species in question; could be regulated or forced (induced).

Ice nucleating agent (INA) Chemical that assists formation of ice nuclei.

ICI: Intracervical Insemination Artificial insemination of sperm into the cervical canal.

Ideal solution Ideal solution or ideal mixture is a solution in which the enthalpy of solution is zero; the change in Gibbs free energy on mixing is determined solely by the entropy of mixing. Any component of an ideal solution obeys Raoult law (*The vapor pressure of an ideal solution is dependent on the vapor pressure of each chemical component and the mole fraction of the component present in the solution*) over the entire composition range.

In-Vitro Fertilization (IVF) Fertilization outside the body – extracorporal fertilization. The procedure where eggs are removed from the ovaries and mixed with sperm. Eggs that fertilize become embryos and are transferred to the uterus in the hopes that a pregnancy will result. Spare embryos are often cryopreserved and placed in storage.

Kinase Enzyme that phosphorylates a molecule.

Latent heat Heat that is released during a phase transition.

Lyophilization Freeze drying; the removal of moisture from a frozen material using sublimation in vacuum.

Lipid Molecule with fatty acid attached to a polar head group.

Lipid peroxidation Degradation by free oxygen radicals.

Mammal Homeothermic animal who give birth to live offspring.

Meiosis The reduction division process resulting in the number of chromosomes in reproductive cells being reduced from 46 to 23.

Metabolism Processes by which organism generates and uses energy.

Membrane phase transition A phase transition alters the membrane fluidity since individual components or domain of the membrane change their phase state at the temperature that depends on the chain length and the saturation level of the individual fatty acids.

Micelle Aqueous solution surrounded by a lipid bilayer.

Microtubules Hollow tubes of polymerized tubulin – part of cytoskeleton.

Mitochondria Site of the energy generation from glucose and oxygen.

Necrosis Cell death by accidental means (e.g., starvation, dehydration, poison, etc.).

Nucleus Organelle that houses the cell's DNA and transcription/translation machinery.

Oocyte A female sex cell (egg or ovum).

Organelle Discrete structure within a cell.

Osmotic shock Cell shrinkage and swelling due to the variation of the concentration of the environment solution, which can lead to the irreversible damage.

Permeability An ability to move across the cellular membrane.

Peterson modulus Also pressure–strain modulus, the measure of the fractional pulsative diameter change that occurs in an artery exposed to a given change in intra-luminal pressure.

Poikilothermic see *Cold-blooded*

Polyethylene glycol A polymer of EG available in the range of Mol. Wt., used in vitrification solutions.

Propanediol (PROH) Also propylene glycol (PG) and 1,2-propanediol. Used for human embryos preservation.

Pulse wave velocity Wave speed related to the artery wall elasticity via Moens-Korteweg equation.

PVP Polyvinylpyrrolidone. Used in CPA and vitrification solutions.

Raffinose A sugar (Mol. Wt. 594.5) used in CPA solution to promote cell dehydration.

Reactive oxygen species (ROS) Highly active charged ions that readily damage biological objects by oxidation.

Recrystallization A process in which individual ice crystals (grains) change size. Small crystals shrink while large grow.

Reflection coefficient A measure of the solute ability to penetrate the membrane.

Rehydration The restoring of the normal cell's water content.

Ribonucleic acid Nucleic acid involved in gene translation.

Seeding Manual or automated initiation of ice nucleation and growth.

Solution effect Cell injury due to long exposure to the hypertonic solution.

Sperm bank A place where sperm is collected and frozen to be used at a later time or donated for use in Assisted Reproductive Technologies (ARTs).

Spermatocyte An immature sperm cell. Diploid primary spermatocytes (2N) undergo the first meiotic division (M1) to form diploid secondary spermatocytes (2N). Secondary spermatocytes (2N) divide meiotically (M2) to form haploid round spermatids (N).

Spermaozoa The male reproductive cell or gamete.

Spindle The construction of fine fibres that holds chromosomes in the metaphase II oocytes.

Stiffness index A measure of the arterial wall stiffness, determined by the systolic and diastolic pressure values and the corresponding systolic and diastolic diameters of the artery.

Sucrose A sugar (Mol. Wt. 342) used in CPA solution to promote cell dehydration, of low toxicity to oocytes and embryos.

Sugars Monosaccharides (fructose, galactose, glucose), disaccharides (maltose, sucrose, trehalose, lactose), or polysaccharides (raffinose).

Surface tension The force per unit length required to increase the area of the surface.

Tachymetabolic see *warm-blooded*

Trehalose A sugar (Mol. Wt. 378.3) used in CPA solution to promote cell dehydration, of low toxicity to oocytes and embryos.

Vesicle Organelle that is enclosed by a lipid membrane.

Vitrification Process of solidification without crystallization.

Warm-blooded Also homeothermic, tachymetabolic. An animal that maintains its body temperature significantly higher the ambient temperature when the latter is low.

Zygote A fertilized oocyte.

References

1. Roche applied science. Apoptosis, cell death and cell proliferation. http://www.sinozhongyuan.com/files/roche/manual_apoptosis.pdf
2. Glossary of verification and validation terms. http://www.grc.nasa.gov/WWW/wind/valid/tutorial/glossary.html
3. Molecular Dynamics Machine. http://atlas.riken.go.jp/mdm/index.html
4. Guide for the verification and validation of computational fluid dynamics simulations. AIAA G-077-1998 (1998)
5. Glossary of terms for thermal physiology, 3rd edn. Jpn. J. Physiol. **51**, 245–280 (2001)
6. A.V. Aarset, Comp. Biochem. Physiol. A **73**, 571–580 (1982)
7. J. Abakali, C.C. Ariahu, N.N. Nkpa, J. Food Process. Preserv. **30**, 597–607 (2006)
8. J.P. Abraham, E.M. Sparrow, Int. J. Heat Mass Transfer **50**, 2537–2544 (2007)
9. J.P. Acker, I.M. Croteau, J. Microsc. **215**, 131–138 (2004)
10. J.P. Acker, J.A.W. Elliot, L.E. McGann, Cryobiology **41**, 354–355 (2000)
11. J.P. Acker, J.A.W. Elliot, L.E. McGann, Biophys. J. **81**, 1389–1397 (2001)
12. J.P. Acker, A. Larese, H. Yang, A. Petrenko, L.E. McGann, Cryobiology **38**, 363–371 (1999)
13. J.P. Acker, X.M. Lu, H. Bayley, A. Fowler, M. Toner, Biotech. Bioeng. **82**, 525–532 (2003)
14. J.P. Acker, L. McGann, Cryo-Letters **19**, 367–374 (1998)
15. J.P. Acker, L. McGann, Cryo-Letters **22**, 241–254 (2001)
16. J.P. Acker, L. McGann, Cryobiology **46**, 197–202 (2003)
17. J.P. Acker, L.E. McGann, Cryobiology **40**, 54–63 (2000)
18. M. Akyurt, G. Zaki, B. Habeebullah, Energy Convers. Manage. **43**, 1773–1789 (2002)
19. M. Alber, F. Nüsslin, Phys. Med. Biol. **44**, 479–493 (1999)
20. A.B. Albu, J.M. Schwartz, D. Laurendeau, C. Moisan, Lect. Notes Comput. Sci. **2673**, 121–131 (2003)
21. A.E. Allworth, D.F. Albertini, Dev. Biol. **158**, 101–112 (1993)
22. K. Aman, E. Lindahl, O. Edholm, P. Hakansson, P.O. Westlund, Biophys. J. **84**, 102–115 (2003)
23. O. Amy, T. Farah, S. Kenneth, W. Alexander, B. Stephen, Opt. Express **13**, 6597–6614 (2005)

24. V. Anchamparuthy, Ph.D. Thesis, Virginia University, 2007
25. C.A. Andorfer, J.G. Duman, J. Insect Physiol. **46**, 365–372 (2000)
26. M.D. Andreews, Am. Family Physician **10**, 2355–2372 (2004)
27. C.A. Angell, in *Water – A Comprehensive Treatise*, ed. by F. Frank (Plenum, New York, 1982), pp. 1–82
28. C.A. Angell, R.D. Bressel, M. Hemmati, E.J. Sare, J.C. Tucker, Phys. Chem. Chem. Phys. **2**, 1559–1566 (2000)
29. C.A. Angell, E.J. Sara, J. Donnella, D.R. MacFarlane, J. Phys. Chem. 1461–1464 (1981)
30. D.A. Anick, J. Mol. Struct. (Theochem) **587**, 87–96 (2002)
31. V.F. Antonov, E.Y. Smirnova, E.V. Shevchenko, *Lipid Membranes in Phase Transformations (in Russian)* (Nauka, Moscow, 1992)
32. A. Arav, S. Yavin, Y. Zeron, D. Natan, I. Dekel, H. Gacitua, Mol. Cell. Endocrin. **187**, 77–81 (2002)
33. D.L. Archer, Int. J. Food Microbiol. **90**, 127–138 (2004)
34. R.A. Armentano, D.B. Santana, E.I.C. Fisher, S. Graf, H.P. Cámpos, Y.Z. Germán, M. del Carmen Saldías, I. Alvarez, Cryobiology **52**, 17–26 (2006)
35. W.J. Armitage, S.C. Hall, C. Routledge, Invest. Ophtalmol. Vis. Sci. **43**, 2160–2164 (2002)
36. W.J. Armitage, B.K. Juos, Cryobiology **46**, 194–196 (2003)
37. W.J. Armitage, B.K. Juos, D.L. Easty, Cryobiology **32**, 52–59 (1995)
38. E. Asahina, in *Cryobiology* ed. by H.T. Meryman (Academic Press, London, 1966) pp. 451–486
39. M.J. Ashwood-Smith, G.B. Friedmann, Cryobiology **16**, 132–140 (1979)
40. M.J. Ashwood-Smith, G.J. Morris, R. Fowler, T.C. Appleton, R. Ashorn, Human Reprod. **3**, 795–802 (1988)
41. E.N. Ashworth, Horticult. Rev. **13**, 215–255 (1992)
42. G.A. Ateshian, M. Likhitpanichkul, C.T. Hung, J. Biomech. **39**, 464–475 (2006)
43. M. Auer, J. Mol. Med. **78**, 191–202 (2000)
44. M.A. Azouni, P. Casses, B. Sergiani, Colloid Surf. A **122**, 199–205 (1997)
45. J. Baardsnes, M. Jelokhani-Niaraki, L.H. Kondejewski, M.J. Kuiper, C.M. Kay, R.S. Hodges, P.L. Davies, Protein Sci. **10**, 2566–2576 (2001)
46. J. Baardsnes, L.H. Kondejewski, R.S. Hodges, H. Chao, C. Kay, P.L. Davies, FEBS Lett. **463**, 87–91 (1999)
47. Y. Bachiri, C. Gazeau, J. Hansz, C. Morisset, J. Dereuddre, Plant Cell Tissue Organ Culture **43**, 241–248 (1995)
48. N.P. Bailey, T. Christensen, B. Jakobsen, K. Niss, N.B. Olsen, U.R. Petersen, T.B. Schroder, J.C. Dyre, J. Phys. Condens. Matter **20**, 244113 (2008)
49. J.W. Baish, J. Biomech. Eng. **116**, 521–527 (1994)
50. J.W. Baish, in *The Biomedical Engineering Handbook*, ed. by J.D. Bonzano, 2nd edn., ch. 98 (CRC Press, West Palm Beach, FL, 2000)
51. R. Baissalov, G.A. Sandison, B.J. Donnelly, J.C. Saliken, J.G. Mckinnon, K. Muldrew, J.C. Rewcastle, Phys. Med. Biol. **45**, 1085–1098 (2000)
52. R. Baissalov, G.A. Sandison, D. Reynolds, K. Muldrew, Phys. Med. Biol. **46**, 1799–1814 (2001)
53. M.B. Baker, M. Baker, Geophys. Res. Lett. **31**, L19102 (2004)
54. A.M. Bakken, Current Stem Cell Res. Therapy **1**, 47–54 (2006)
55. S.K. Balasubramanian, S. Bandyopadhyay, S. Pal, B. Bagchi, Curr. Sci. **85**, 1571–1578 (2003)

56. S.K. Balasubramanian, J.C. Bischof, A. Hubel, Cryobiology **52**, 62–73 (2006)
57. S.K. Balasubramanian, S. Pal, B. Bagchi, Phys. Rev. Lett. **89**, 115505 (2002)
58. S.K. Balasubramanian, S. Pal, B. Bagchi, J. Indian Inst. Sci. **83**, 27–51 (2003)
59. W.B. Bald, J. Fraser, Rep. Prog. Phys **45**, 1381–1434 (1982)
60. R.L. Baldwin, in *Protein Folding Handbook*, ed. by J. Buchner, T. Kiefhaber (Wiley, Weinheim, 2005), pp. 3–21
61. J.S. Bale, Eur. J. Entomol. **93**, 369–382 (1996)
62. J.S. Bale, Phil. Trans. R. Soc. Lond. B **357**, 955–956 (2002)
63. J.S. Bale, Phil. Trans. R. Soc. Lond. B **357**, 849–862 (2002)
64. D.A. Balentine, S.A. Wiseman, L.C.M. Bouwens, Crit. Rev. Food Sci. Nutr. **37**, 693–704 (1997)
65. B.A. Ball, A. Vo, J. Androl. **6**, 1061–1069 (2001)
66. H. Bank, P. Mazur, J. Cell Biol. **57**, 729–742 (1973)
67. K. Barbee, Ann. N.Y. Acad. Sci. **1066**, 1–18 (2005)
68. C.A.V. Barker, J.C.C. Gandlier, Can. J. Compar. Med. Veterin. Sci. **21**, 47–51 (1957)
69. D.M. Barrett, E. Garcia, J.E. Wayne, Crit. Rev. Food Sci. Nutr. **38**, 173–258 (1998)
70. R. Barrett, M. Berry, T.F. Chan, J. Demmel, J. Donato, J. Dongarra, V. Eijkhout, R. Pozo, C. Romine, H.V. der Vorst, *Templates for the Solution of Linear Systems: Building Blocks for Iterative Methods*, 2nd edn. (SIAM, Philadelphia, PA, 1994)
71. T.J. Bart, Aspects of unstructured grids and finite-volume solvers for the Euler and Navier–Stokes equations. AGARD Report 787 (1992)
72. V.V. Barun, A.P. Ivanov, Int. J. Heat Mass Transfer **46**, 3243–3254 (2003)
73. G.K. Batchelor, *An Introduction to Fluid Dynamics* (Cambridge University Press, Cambridge, 1967)
74. R.P. Batycky, R. Hammerstedt, D.A. Edwards, Phil. Trans. R. Soc. Lond. A **355**, 2459–2488 (1997)
75. S. Bauerecker, P. Ulbig, V. Buch, L. Vrbka, P. Jungwirth, J. Phys. Chem. C **112**, 7631–7636 (2008)
76. A. Baumgaertner, S. Grudinin, J.F. Gwan, NIC Series **20**, 365–375 (2003)
77. J.G. Baust, J.M. Baust (eds.), *Advances in Biopreservation*. (CRC Press, West Palm Beach, FL, 2006)
78. J.G. Baust, A.A. Gage, BJU Int. **95**, 1187–1191 (2005)
79. J.G. Baust, A.A. Gage, D. Clarke, J.M. Baust, R. van Buskirk, Cryobiology **48**, 190–204 (2004)
80. E.H. Beck, S. Fettig, C. Knake, K. Hartig, T. Bhattarai, J. Biosci. **32**, 501–510 (2007)
81. E.H. Beck, R. Heim, J. Hansen, J. Biosci. **29**, 449–459 (2004)
82. S.M. Becker, A.V. Kuznetsov, Int. J. Heat Mass Transfer **50**, 105–116 (2007)
83. D.J. Beerling, A.C. Terry, P.L. Mitchell, T.V. Callaghan, D. Gwynn-Jones, J.A. Lee, Am. J. Botany **88**, 628–633 (2001)
84. Y. Belhamadia, A. Fortin, E. Chamberland, J. Comput. Phys. **194**, 233–255 (2004)
85. Y. Belhamadia, A. Fortin, E. Chamberland, J. Comput. Phys. **201**, 753–770 (2004)
86. M.C. Bellissent-Funel, Eur. J. Phys. E **12**, 83–92 (2003)
87. W.S. Benedict, N. Gailar, E.K. Plyler, J. Chem. Phys. **24**, 1139–1165 (1956)

88. M. Beneś, Acta. Math. Univ. Comenianae **LXX**, 123–151 (2001)
89. L. Beney, I.M. de Marañón, P.A. Marechal, S. Moundanga, P. Gervais, Biochem. Eng. J. **9**, 205–210 (2001)
90. E.E. Benson, P.T. Lynch, J. Jones, Plant. Sci. **85**, 107–114 (1992)
91. H.J.C. Berendsen, S.J. Marrink, Pure Appl. Chem. **65**, 2513–2520 (1993)
92. A. Berezhkovskii, G. Hummer, Phys. Rev. Lett. **89**, 064503 (2002)
93. B.A. Berg, Fields Inst. Commun. **26**, 1–24 (2000)
94. W.K. Berger, J. Poledna, Int. J. Colorectal Dis. **16**, 331–339 (2001)
95. W.K. Berger, B. Uhrík, Experientia **52**, 843–850 (1996)
96. E.J. Berjano, BioMed. Eng. Online **6**, 1–17 (2006)
97. A. Bernard, B.J. Fuller, Human Reprod. Update **2**, 193–207 (1996)
98. M. Bhattacharya, T. Basak, K.G. Ayappa, Int. J. Heat Mass Transfer **45**, 4881–4898 (2002)
99. P. Bianko, P.G. Robey, Nature **414**, 118–121 (2001)
100. V.N. Bingi, A.V. Savin, Phys. Usp. **46**, 259–292 (2003)
101. H. Bird, Anaesthesia **4**, 10–17 (1949)
102. J. Bischof, X. He, Ann. N.Y. Acad. Sci. **1066**, 1–22 (2005)
103. J.C. Bischof, B. Mahr, J.H. Choi, M. Behling, D. Mewes, Annals Biomed. Eng. **35**, 292–304 (2007)
104. J.C. Bischof, W.F. Wolkers, N.M. Tsvetkova, A.E. Oliver, J.H. Crowe, Cryobiology **45**, 22–32 (2002)
105. J.C. Bishof, Heat Mass Transfer **42**, 955–966 (2006)
106. J.C. Bishof, D. Smith, P.V. Pazhyannur, C. Manivel, J. Hulbert, K.P. Roberts, Cryobiology **34**, 42–69 (1997)
107. S.N. Bizunok, E.N. Sventitskii, *Water in Biological Systems and their Components* (in Russian), (Leningrad State University, Russia, 1983)
108. A.R. Bizzarri, S. Cannistraro, J. Phys. Chem. B **106**, 6617–6633 (2002)
109. H.D. Blackburn, Reprod. Fertil. Dev. **16**, 27–32 (2004)
110. J.M. Blanco, G. Gee, D.E. Wildt, A.M. Donoghue, Biol. Reprod. **63**, 1164–1171 (2000)
111. J.M. Blanco, J.A. Long, G. Gee, A.M. Donoghue, D.E. Wildt, Cryobiology **56**, 8–14 (2008)
112. M.V. Bogdanov, D.K. Ofengeim, A.I. Zhmakin, Cent. Eur. J. Phys. **2**, 183–203 (2004)
113. A.A. Boldyrev, E.I. Kyaivyaryainen, V.A. Ilyukha, *Biomembranology* (in Russian) (Inst. Biology Karelia Sci. Center, Russian Academy of Sciences, Petrzavodsk, 2006)
114. B.A. Boley, J.H. Weiner, *Theory of Thermal Stresses* (Wiley, New York, 1960)
115. D.L. Bostick, Ph.D. Thesis, University of North Carolina, Chapel Hill, 2004
116. D.J. Boules, P.J. Lillford, D.A. Rees, I.A. Shanks, Phil. Trans. R. Soc. Lond. B **357**, 829 (2002)
117. P. Boutron, J. Phys. Chem. **87**, 4273–4276 (1983)
118. V. Bouvet, R.E. Ben, Cell Biochem. Biophys. **39**, 133–144 (2003)
119. R.E. Bower, B.G. Carbo, M.M. Pace, E.F. Graham, J. Anim. Sci. **36**, 319–324 (1973)
120. D.T. Bowron, Phil. Trans. R. Soc. Lond. B **359**, 1167–1180 (2004)
121. N.K. Brahma, Trends Biomater. Artif. Organs **17**, 17–23 (2004)
122. C. Branca, S. Magazu, G. Maisano, P. Migliardo, P.G. Mineo, Physica Scripta **64**, 390–397 (2001)

123. G. Brannigan, L.C.L. Lin, F.L.H. Brown, Eur. Biophys. J. **35**, 104–124 (2006)
124. I. Braslavsky, S.G. Lipson, Appl. Phys. Lett. **72**, 264–266 (1998)
125. I. Braslavsky, S.G. Lipson, J. Cryst. Growth **198/199**, 56–61 (1999)
126. J.W. Breman, Ph.D. Thesis, University of Florida, 2006
127. S.E. Bresler, Sov. Phys. Usp. **18**, 62–73 (1975)
128. G. Breton, J. Danyluk, F. Ouellet, F. Sarhan, Biotechnol. Annu. Rev. **6**, 57–99 (2000)
129. E.M. Brey, T.W. King, C. Johnson, L.V. McIntire, G.P. Reece, C.W. Patric, Microvasc. Res. **63**, 279–294 (2002)
130. W.J. Briels, H.L. Tepper, Phys. Rev. Lett. **79**, 5074–5077 (1997)
131. K.G.M. Brockbank, K.M. Smith, Transplant Proc. **25**, 3185 (1993)
132. R.G.M. Brockbank, J.R. Walsh, Y.C. Song, M.J. Taylor, in *Topics in Tissue Engineering*, ed. by N. Ashammakhi, P. Ferretti, ch.12, e-book, http://www.oulu.fi/spareparts/ebook_topics_in_t_e/abstracts/brockbank_1.pdf (2003)
133. V.L. Bronstein, P.L. Steponkus, Cryobiology **32**, 1–22 (1995)
134. I. Brovchenko, A. Oleinikova, in *11th Int. Conf. on the Physics and Chemistry of Ice (PCI-2006)*, Bremerhaven, Germany, July 2006, Abstracts. ed. by F. Wilhelms, W.F. Kuhs, p. O016
135. C.L. Brown, J.S. Bale, K.F.A. Walters, Proc. Roy. Soc. Lond. B **271**, 1507–1511 (2004)
136. R.A. Brush, M. Griffith, A. Mlynarz, Plant Physiol. **104**, 725–735 (1994)
137. G. Bryant, K.L. Koster, J. Wolfe, Seed Sci. Res. **11**, 17–25 (2001)
138. G. Bryant, J. Wolfe, Eur. Biophys. J. **16**, 369–374 (1989)
139. G. Bryant, J. Wolfe, Cryo-Letters **13**, 23–36 (1992)
140. M.K. Bucci, A. Bevan, M. Roach, CA Cancer J. Clin. **55**, 117–134 (2005)
141. V. Buch, S. Bauerecker, J.P. Devlin, U. Buck, J.K. Kazimirski, Int. Rev. Phys. Chem. **23**, 375–433 (2004)
142. S. Bucharan, S. Cross, J.P. Acker, M. Toner, J.F. Carpenter, D. Pyatt, Exp. Hemotol. **30**, 131 (2002)
143. S.V. Buldyrev, P. Kumar, P.G. Debenedetti, P.J. Rossky, H.E. Stanley, Proc. Natl. Acad. Sci. USA **104**, 20177–20182 (2007)
144. F.V. Bunkin, G.A. Lyakhov, K.F. Shipilov, Phys. Usp. **38**, 1099–1118 (1995)
145. Y.G. Bushev, S.V. Davletbaeva, F. Muguet, Molecules **8**, 226–242 (2003)
146. C. Buzano, E. De Stefanis, M. Pretti, J. Chem. Phys. **126**, 074904 (2007)
147. V.M. Byakov, S.V. Stepanov, Phys. Usp. **49**, 467–487 (2006)
148. C. Körber, M. Schiewe, K. Wollhöver, Int. J. Heat Mass Transfer **26**, 1241–1253 (1983)
149. A. Cahoon, M. Maruyama, J.S. Wettlaufer, Phys. Rev. Lett. **96**, 255502 (2006)
150. G. Caldarelli, P. de los Rios, J. Biol. Phys. **27**, 229–241 (2001)
151. L.H. Campbell, K.G.M. Brockbank, In Vitro Cell. Dev. Biol. Animal **43**, 269–275 (2007)
152. J.R. Cannon, E. DiBenedetto, G.H. Knightly, Arch. Ration. Mech. Anal. **73**, 79–97 (1980)
153. M.A. Carignano, P.B. Shepson, I. Szleifer, Mol. Phys. **103**, 2957–2967 (2005)
154. M. Carin, M. Jaeger, Eur. Phys. J. Appl. Phys. **16**, 231–238 (2001)
155. K.A. Carnevale, M.S. Thesis, Georgia Institute of Technology, 2004
156. G.G. Caro, T.J. Pedley, R.C. Schroter, W.A. Seed, *The Mechanics of Circulation* (Oxford University Press, Oxford, 1978)

157. J.F. Carpenter, T.N. Hansen, Proc. Natl. Acad. Sci. USA **89**, 8953–8957 (1992)
158. D.C. Carter, K. Lim, J.X. Ho, B.S. Wright, P.D. Twigg, T.Y. Miller, J. Chapman, K. Keeling, J. Ruble, P.G. Vekilov, B.R. Thomas, F. Rosenberger, A.A. Chernov, J. Cryst. Growth **196**, 623–637 (1999)
159. J. Cavender-Bares, in *Vascular Transport in Plant*, ed. by N.M. Holbrook, M. Zwieniecki, P. Melcher (Elsevier, Oxford, 2005), pp. 401–424
160. G. Cevc, in *Handbook of Biological Physics*, ed. by R. Lipowsky, E. Sackmann (Elsevier, Amsterdam, 1995), pp. 465–490
161. J. Chakrabarty, D. Banerjee, D. Pal, J. De, A. Ghosh, G.C. Majumder, Cryobiology **54**, 27–35 (2007)
162. R. Chambers, P. Halle, Proc. Roy. Soc. **B110**, 336–352 (1932)
163. N.H. Chao, C.P. Chiang, H.W. Hsu, C.T. Tsai, T.T. Lin, Aquat. Living Resour. **7**, 99–104 (1994)
164. M. Chaplin, Sixty-three anomalies of water. http://www.lsbu.ac.uk/water/anomlies.html
165. M.F. Chaplin, Biophys. Chem. **83**, 211–221 (1999)
166. S. Chapman, T.G. Cowling, *The Mathematical Theory of Non-Uniform Gases*, 3rd edn. (Cambridge University Press, Cambridge, 1970)
167. C.K. Charny, S. Weinbaum, R.L. Lewin, J. Biomech. Eng. **112**, 80–87 (1990)
168. J.C. Chato, J. Biomech. Eng. **102**, 110–118 (1980)
169. M.K. Chattopahyay, Resonance 25–30 (2007)
170. C. Chen, Lancet **1**, 884–886 (1986)
171. G. Chen, Z. Jia, Biophys. J. **77**, 1602–1608 (1999)
172. M. Chen, W. Huang, J. Zhejiang Univ. Sci. B **7**, 7–12 (2006)
173. M.M. Chen, K.R. Holmes, Ann. N.Y. Acad. Sci. **335**, 137–150 (1980)
174. S. Chen, B. Merrimam, S. Osher, P. Smekerka, J. Comput. Phys. **135**, 8–29 (1997)
175. S.H. Chen, L. Liu, X. Chu, Y. Zhang, E. Fratini, P. Baglioni, A. Faraone, E. Mamontov, J. Chem. Phys. **125**, 171103 (2006)
176. S.H. Chen, F. Mallamace, C.Y. Mou, M. Broccio, C. Corsaro, A. Faraone, L. Liu, Proc. Natl. Acad. Sci. USA **103**, 12974–12978 (2006)
177. S.Y. Chen, G.D. Doolen, Ann. Rev. Fluid Mech. **30**, 329–364 (1998)
178. T. Chen, J.P. Acker, S. Cheley, H. Bayley, A. Fowler, M. Toner, Cryobiology **43**, 168–181 (2001)
179. A. Cheng, K.M. Merz, Biophys. J. **73**, 2851–2873 (1997)
180. C.H.C. Cheng, in *Encyclopedia of Life Support Systems (EOLSS) – Theme 6.73 Extremophiles* (ed. by C. Gerday), Developed under the auspices of the UNESCO (Eolss Publishers, UK, 2003)
181. H. Cheng, D. Plewes, J. Magn. Reson. Imaging **16**, 598–609 (2002)
182. Y.K. Cheng, P.J. Rossky, Nature **392**, 696–699 (1998)
183. A.A. Chernov, J. Cryst. Growth **174**, 354–361 (1997)
184. A.A. Chernov, D.E. Temkin, A.M. Mel'nikova, Sov. Phys. Crystallogr. **22**, 656–658 (1977)
185. R. Chidamaram, S.K. Sikka, Curr. Sci. **85**, 871–880 (2003)
186. A.N. Chimenkov, A.B. Brushkov, *Introduction to Structural Cryology* (in Russian) (Nauka, Moscow, 2006)
187. B. Choi, T.E. Milner, J. Kim, J.N. Goodman, G. Vargas, G. Aguilar, J.S. Nelson, J. Biomed. Optics **9**, 282–286 (2005)

188. E.M. Choi, Y.H. Yoon, S. Lee, H. Kang, Phys. Rev. Lett. **95**, 085701-1–4 (2005)
189. J.H. Choi, B. Han, J.C. Bishof, in ASME International Mechanical Engineering Congress and Exposition, Anaheim, USA, 2004, pp. 1–2
190. K.J. Chua, S.K. Chou, J.C. Ho, J. Biomech. **40**, 100–116 (2007)
191. A.F. Chudnovskii, *Physics of Heat Transfer in Soil* (in Russian). (OGIZ. Gostechizdat, Leningrad, Moscow, 1948)
192. T.A. Churchill, K.B. Storey, J. Comp. Physiol. **B 164**, 492–498 (1994)
193. G. Cicero, J.C. Grossman, A. Catellani, G. Galli, Water at a hydrophilic solid surface probed by ab-initio molecular dynamics: inhomogeneous thin layers of dense fluid. Tech. Rep. UCRL-JRNL-209874, Lawrence Livermore Nat. Lab., 2005
194. D.M. Clarke, J.M. Baust, R.G.V. Buskirk, J.G. Baust, Cryobiology **42**, 274–285 (2001)
195. D.M. Clarke, J.M. Baust, R.G.V. Buskirk, J.G. Baust, Cryobiology **49**, 45–61 (2004)
196. J.P. Cobb, R.S. Hotchkiss, I.E. Karl, T.G. Buchman, Br. J. Anaesth. **77**, 3–10 (1996)
197. Y. Cognié, G. Barill, N. Poulin, P. Mermillord, Theriogenology **59**, 171–188 (2003)
198. G. Comini, S.D. Guidice, ASME J. Heat Transfer **98**, 543–549 (1976)
199. G. Comini, S.D. Guidice, R.W. Lewis, O.C. Zienkiewicz, Int. J. Numer. Meth. Eng. **8**, 613–624 (2005)
200. Commission on Genetic Resources for Food and Agriculture – FAO of the UN, The State of the World's Animal Genetic Resouces for Food and Agriculture. FAO, Rome, 2007
201. Committee on the Mathematics and Physics of Emerging Dynamic Biomedical Imaging, Mathematics and Physics of Emerging Biomedical Imaging. National Academy Press, Washington, DC, 1996
202. M. Conzemius, T. Brown, Y. Zhang, R. Robinson, J. Orthoped. Res. **20**, 303–309 (2002)
203. I.S. Cooper, A. Lee, J. Nerve Mental. Dis. **33**, 259–263 (1961)
204. I.S. Cooper, A. Lee, J. Am. Geriatr. Soc. **9**, 714–718 (1961)
205. S.M. Cooper, R.P.R. Dawber, J.R. Soc. Med. **94**, 196–201 (2001)
206. T.E. Cooper, G.J. Trezek, Cryobilogy **7**, 79–87 (1970)
207. T.E. Cooper, G.J. Trezek, Aerospace. Med. **42**, 24–27 (1971)
208. J. Corsini, C. Hacker, C. Bare, Biol. Proced. Online **6**, 61–65 (2004)
209. J.P. Costanzo, P.J. Baker, R.E. Lee, J. Comp. Physiol. B **176**, 697–707 (2006)
210. J.P. Costanzo, C. Grenot, R.E. Lee, J. Comp. Physiol. B **165**, 238–244 (1995)
211. G. Coticchio, L. De Santis, G. Rossi, A. Borini, D. Albertini, G. Scaravelli, C. Alecci, V. Bianchi, S. Nottola, S. Cecconi, Human Reprod. **21**, 1771–1776 (2006)
212. B.G. Crabo, AAEP Proc. **47**, 291–295 (2001)
213. O. Craciunescu, T.S. Clegg, Adv. Heat Mass Transfer. Biotechnol. HTD **335**, 193–198 (1997)
214. O. Craciunescu, S.K. Das, M.K. Dewhirst, Adv. Heat Mass Transfer Biotechnol. HTD **363**, 9–13 (1999)
215. J. Crezee, J.J.W. Lagendjik, Phys. Med. Biol. **37**, 1321–1337 (1992)
216. J.H. Crowe, L.M. Crowe, J.F. Carpenter, A.S. Rudolph, C.A. Wistrom, B.J. Spargo, T.J. Anchordoguy, Biochim. Biophys. Acta **947**, 367–384 (1989)

217. J.H. Crowe, L.M. Crowe, D. Chapman, Science **223**, 701–703 (1984)
218. Z.F. Cui, J.C. Barbene, Phys. Med. Biol. **36**, 1607–1620 (1991)
219. M.R. Curry, in *Methods in Molecular Biology*, vol. 38, ed. by J.G. Day, M.R. McLellan (Humana Press, Totowa, NJ, 1995) pp. 189–197
220. M.R. Curry, J.D. Millar, P.F. Watson, Biol. Reprod. **51**, 1014–1021 (1994)
221. N. Dabak, Y. Tomak, A. Piskin, B. Gulman, H. Ozcan, Int. Orthopaedics **27**, 249–253 (2003)
222. Z. Dagan, S. Weinbaum, L.M. Jiji, J. Biomech. Eng. **108**, 89–96 (1986)
223. E. Dahlke, D.G. Truhlar, J. Phys. Chem. B Lett. **110**, 10595–10601 (2006)
224. S. D'Amico, P. Claverie, T. Collins, D. Georlette, E. Gratia, A. Hoyoux, M.A. Meuwis, G. Feller, C. Gerday, Phil. Trans. R. Soc. Lond. B **357**, 917–925 (2002)
225. J.G. Dash, A.W. Rempel, J.S. Wettlaufer, Rev. Mod. Phys. **78**, 695–741 (2006)
226. R.V. Davalos, L.M. Mir, B. Rubinsky, Ann. Biomed. Eng. **33**, 223–231 (2005)
227. R.V. Davalos, B. Rubinsky, L.M. Mir, Bioelectrochemistry **61**, 99–107 (2003)
228. R.L. Davidchack, B.B. Laird, Phys. Rev. Lett. **85**, 4751–4754 (2000)
229. P.L. Davies, J. Baardsnes, M.J. Kuiper, V.K. Walker, Phil. Trans. R. Soc. Lond. B **357**, 927–935 (2002)
230. S.H. Davis, *Theory of Solidification*. (Cambridge University Press, Cambridge, UK, 2001)
231. E.V. Davydov, I.A. Lubashevsky, V.A. Milyaev, R.F. Musin, Nondiffusive heat transfer in muscle tissue. Preliminary results. arXiv: cond-mat/0102006 (2001)
232. J.G. Day, G.N. Stacey (eds.), *Cryopreservation and Freeze-Drying Protocols (Methods in Molecular Biology)* (Humana Press, Totowa, NJ, 2007)
233. K.A. De Bruin, W. Krassowska, Biophys. J. **77**, 1213–1224 (1999)
234. P.G. Debenetti, J. Phys.: Condens. Matter **15**, R1669–R1726 (2003)
235. A.E. Delgado, D.W. Sun, J. Food. Eng. **47**, 157–174 (2001)
236. B.N. Delone, Rep. Acad Sci USSR, VII Serie, Dept. Math. Natur. Sci. **7**, 793–800 (1934)
237. G. Deng, D.W. Andrews, R.A. Laursen, FEBS Lett. **402**, 17–20 (2003)
238. Z.S. Deng, J. Liu, Phys. A **300**, 521–530 (2001)
239. Z.S. Deng, J. Liu, Comput. Biol. Med. **34**, 8 (2004)
240. Z.S. Deng, J. Liu, Eng. Anal. Bound. Elem. **28**, 97–108 (2004)
241. Z.S. Deng, J. Liu, Lect. Notes Comput. Sci. **3314**, 437–442 (2004)
242. Z.S. Deng, J. Liu, Cryobiology **50**, 183–192 (2005)
243. Z.S. Deng, J. Liu, Num. Heat Transfer, Part A **49**, 47–67 (2006)
244. Z.S. Deng, J. Liu, H.W. Wang, Int. J. Thermal Sci., Available online 29 June 2007 (2007)
245. D.L. Denlinger, R.E. Lee, in *Temperature Sensitivity in Insects and Application in Integrated Pest Management*, ed. by G.J. Hallman, D.L. Denlinger (Westview Press, Boulder, 1998) pp. 55–95
246. B. Dennis, G. Dulikravich, Y. Rabin, in *IMECE 2000*, Orlando, FL, 5–10 Nov, HTD-Vol. 368/BED-Vol. 47, 2000, pp. 33–48
247. P. Deuflhard, R. Hochmuth, Multiscale analysis of thermoregulation in the human microvascular system. ZIB–Report, 02–31 (2002)
248. P. Deuflhard, V. Mehrmann, *Numerical Analysis and Scientific Computing in Key Technologies* (DFG Research Center Mathematics for Key Technologies, Berlin, 2002) pp. 9–21

249. P. Deuflhard, M. Seebass, D. Stalling, R. Beck, H.C. Hege, *Hyperthermia Treatment Planning in Clinical Cancer Therapy: Modelling, simulation, and visualization* (Konrad-Zuse-Zentrum, Berlin, 1997) Preprint SC 97–26
250. R.V. Devireddy, J.E. Coad, J.C. Bischof, Cryobiology **42**, 225–243 (2001)
251. R.V. Devireddy, P.H. Leo, J.S. Lowengrub, J.C. Bischof, Int. J. Heat Mass Transfer **45**, 1915–1931 (2002)
252. R.V. Devireddy, D. Raha, J.C. Bischof, Cryobiology **36**, 124–155 (1998)
253. R.V. Devireddy, D.J. Swanlund, A.S. Alghamdi, L.A. Duoos, M.H.T. Troedsson, J.C. Bischof, K.P. Roberts, Reproduction **124**, 643–648 (2002)
254. R.V. Devireddy, D.J. Swanlund, K.P. Roberts, J.C. Bischof, Biol. Reprod. **61**, 764–775 (1999)
255. R.V. Devireddy, D.J. Swanlund, K.P. Roberts, J.L. Pryor, J.C. Bischof, Human Reprod. **15**, 1125–1135 (2000)
256. A. DeVries, Science **172**, 1152–1155 (1971)
257. A. DeVries, Phil. Trans. R. Soc. Lond. B **304**, 575–588 (1984)
258. A. DeVries, D. Wohlshlag, Science **163**, 1073–1075 (1969)
259. K.A. Dill, Biochemistry **24**, 1501–1509 (1985)
260. K.A. Dill, T.M. Truskett, V. Vlachy, B. Hribar-Lee, Ann. Rev. Biophys. Biomol. Struct. **34**, 173–199 (2005)
261. K.R. Diller, Cryo-Letters **17**, 201–212 (1996)
262. K.R. Diller, Cryobiology **34**, 304–314 (1997)
263. K.R. Diller, J. Biomech. Eng. **127**, 67–84 (2005)
264. J.P. Ding, B. Pickard, Plant J. **3**, 713–720 (1993)
265. G.S. Do, Y. Sagara, M. Tabata, K. Kudoh, T. Higuchi, Int. J. Refrigeration **27**, 184–190 (2004)
266. A.M. Dokter, S. Woutersen, H.J. Bakker, J. Chem. Phys. **126**, 124,507 (2007)
267. V. Donikier, J.L. VanLaethem, B. Ickx, D. VanGansbeke, S. Goldman, M. Gelin, Acta Chir. Belg. **103**, 452–457 (2003)
268. A.M. Donoghue, G.J. Wishart, Animal Reprod. Sci. **62**, 213–232 (2000)
269. T.A. Driscoll, K.L. Maki, SIAM Review **49**, 673–692 (2007)
270. N. Du, X.Y. Liu, C.L. Hew, J. Biol. Chem. **278**, 36000–36004 (2003)
271. T.S. Dubko, *Visnik Kharkivskogo natsion. Univ. im. V.N. Karazina, Serie: Biology* (2006) pp. 221–231
272. J.G. Duman, J. Comp. Physiol. **B 172**, 163–168 (2002)
273. J.G. Duman, A.S. Serianni, J. Insect Physiol. **48**, 103–111 (2002)
274. D. Dumet, F. Engelmann, N. Chabrillange, Y. Duval, Plant Cell Rep. **12**, 352–355 (1993)
275. F. Dumont, P.A. Marechal, P. Gervais, Cryobiology **46**, 33–42 (2003)
276. F. Dumont, P.A. Marechal, P. Gervais, Appl. Environ. Microbiol. **70**, 268–272 (2004)
277. F. Dumont, P.A. Marechal, P. Gervais, Appl. Environ. Microbiol. **72**, 21330–21335 (2006)
278. J.W. Durkee, P.P. Antich, Phys. Med. Biol. **36**, 1377–1406 (1991)
279. J.W. Durkee, P.P. Antich, Phys. Med. Biol. **36**, 345–368 (1991)
280. J.W. Durkee, P.P. Antich, C.E. Lee, Phys. Med. Biol. **35**, 847–867 (1990)
281. J.W. Durkee, P.P. Antich, C.E. Lee, Phys. Med. Biol. **35**, 869–889 (1990)
282. C. Eck, P. Knaber, S. Korotov, J. Comput. Phys. **178**, 58–80 (2002)
283. K. Edashige, S. Ota, M. Tanaka, D. Valdez, S. Seki, T. Hara, B. Jin, M. Kasai, *Cryo 2006*, Abstract Book, (Hamburg, 2006) p. 50

284. J.F. Edd, L. Horowitz, R.V. Davalos, L.M. Mir, B. Rubinsky, IEEE Trans. Biomed. Eng. **53**, 1409–1415 (2006)
285. J.F. Edd, L. Horowitz, B. Rubinsky, IEEE Tras. Biomech. Eng. **52**, 695–701 (2005)
286. J.F. Edd, B. Rubinsky, Physiol. Meas. **27**, S175–S185 (2006)
287. M. Eddin, Nat. Rev. Mol. Cell Biol. **4**, 414–418 (2003)
288. H.E. Edelhauser, D.L. van Horn, A.B. Gallum, R.O. Schultz, Invest. Ophthalmol. **10**, 100–107 (1971)
289. Y.Y. Efimov, J. Struct. Chem. (in Russian) **42**, 1122–1132 (2001)
290. F. Egelmann, In Vitro Cell. Dev. Biol. Plant **40**, 427–433 (2004)
291. Y.E. Egorov, A.O. Galyukov, A.I. Zhmakin, Lect. Notes Comput. Sci. **8**, 267–277 (1999)
292. Y.E. Egorov, A.I. Zhmakin, Comp. Mat. Sci. **11**, 204–220 (1998)
293. V. Ekstrand, Ph.D. Thesis, Karolinska Institutet, Stockholm, 2005
294. I. El-Danasouri, H. Selman, Middle East Fertil. Soc. J. **10**, 205–206 (2005)
295. I. Emsminger, F. Busch, N.P.A. Hunter, Physiol. Plant. **126**, 28–44 (2006)
296. F. Engelmann, in *Cryopreservation of Tropical Plant Germplasm – Current Research Progress and Applications* ed. by F. Engelmann, H. Takagi (IPGRI, 2000) pp. 8–20
297. F. Engelmann, H. Takagi, (eds.), *Cryopreservation of Tropical Plant Germplasm – Current Research Progress and Applications* (Internal Plant Genetic Resources Institute, 2000)
298. N.J. English, D.A. Mooney, J. Chem. Phys. **126**, 091,105 (2007)
299. P. Enthel, W.A. Adeagbo, M. Sugihara, G. Rollmann, A.T. Zayak, M. Kreth, K. Kadau, Lect. Notes Phys. **642**, 177–206 (2004)
300. T. Erdey-Gruz, *Transport Phenomena in Aqueous Solutions* (Wiley, New York, 1974)
301. S. Eriksson, R. Hurme, M. Rhen, Phil. Trans. R. Soc. Lond. B **357**, 887–893 (2002)
302. J.A. Ernst, R.T. Clubb, H.X. Zhou, A.M. Gronenborn, G.M. Clore, Science **267**, 1813–1817 (1995)
303. A. Eroglu, M.J. Russo, R. Bieganski, A. Fowler, S. Cheley, H. Bayley, M. Toner, Nat. Biotechnol. **18**, 163–167 (2004)
304. J.R. Errington, P.G. Debenedetti, Nature **409**, 318–321 (2001)
305. F.M. Etzler, in *Inst. Paper Sci. Technol. Tech. Paper Series No. 347*, Atlanta, 1990, pp. 1–38
306. W. Evans, J. Fish, P. Keblinski, Thermal conductivity of ordered molecular water. Lockheed Martin Corp. Rep. LM-06K008, 2006
307. G.M. Fahy, J. Saur, R.J. Williams, Cryobiology **26**, 569–570 (1989)
308. G.M. Fahy, B. Wowk, J. Wu, Rejuvenation Res. **9**, 279–291 (2006)
309. G.M. Fahy, B. Wowk, J. Wu, S. Paynter, Cryobiology **48**, 22–35 (2004)
310. M. Falconi, M. Brunelli, A. Pesce, M. Ferrario, M. Bolognesi, A. Desideri, Proteins Struct. Funct. Genet. **51**, 607–615 (2003)
311. I. Farup, A. Mo, Metall. Mater. Trans. A **31**, 1461–1472 (2000)
312. M.E. Feder, G.E. Hofmann, Annu. Rev. Physiol. **61**, 243–282 (1999)
313. Y.B. Fei, L.B. Wei, S.Q. Gao, M.C. Lu, B.H. Wang, Z.F. Li, Y.M. Zhang, N.H. Shu, Y. Jiang, W.X. Wang, Chin. Sci. Bull. **46**, 495–498 (2001)
314. R.G. Fernández, J.L.F. Abascal, C. Vega, J. Chem. Phys. **124**, 144, 506 (2006)
315. Y.P. Filippov, A.P. Vasilkov, Eng. Phys. J. (in Russian) **36**, 1100–1107 (1979)

316. A.V. Finkelstein, O.B. Ptitsyn, *Physics of Protein* (in Russian) (Institute of Protein RAS, Moscow, 2002)
317. J.L. Finney, Phil. Trans. R. Soc. Lond. B **359**, 1145–1165 (2004)
318. J.L. Finney, J. Phys. Conf. Series **57**, 40–52 (2007)
319. G. Flash, M. Özisik, Numer. Heat Transfer A **16**, 249–266 (1989)
320. G.L. Fletcher, C.L. Hew, P.L. Davies, Ann. Rev. Physiol. **63**, 359–390 (2001)
321. F. Fonseca, M. Martin, G.I. Morris, Appl. Environm. Microbiol. **72**, 6472–6482 (2006)
322. R.H. Foote, J. Anim. Sci. **80**, 1–10 (2002)
323. V. Forest, M. Peoćh, L. Campos, D. Guyotat, J.M. Vergnon, Cryobiology **50**, 29–37 (2005)
324. A. Fortin, Y. Belhamadia, Comput. Meth. Biomech. Biomed. Eng. **8**, 241–249 (2005)
325. W. Franco, G.X. Wang, J.S. Nelson, G. Aguilar, in *ASME Int. Mech. Eng. Congr. and Exhib. ASME 2004* 59609 (2004)
326. F. Franks, Phil. Trans. R. Soc. Lond. A **361**, 557–574 (2003)
327. G. Franzese, G. Malescio, A. Skibinsky, S.V. Buldyrev, H.E. Stanley, Nature **409**, 692–695 (2001)
328. G. Franzese, H.E. Stanley, Understanding the unusual properties of water. ArXiv:cond-mat/0603634 [cond-mat.soft]
329. G. Franzese, H.E. Stanley, J. Phys. Condens. Matter **19**, 205126(16) (2007)
330. K.L. Fredrickson, Ph.D. Thesis, University of Wisconsin-Madison, 2004
331. R.C. de Freitas, K.R. Diller, Cell Preserv. Technol. **2**, 19–28 (2004)
332. R.C. de Freitas, K.R. Diller, J.R.T. Lakey, R.V. Rajotte, Cryobiology **35**, 230–239 (1997)
333. S. Fujikawa, J. Cell Sci. **49**, 369–382 (1981)
334. A.A. Gage, Semin. Surg. Oncol. **14**, 99–109 (1998)
335. A.A. Gage, J. Baust, Cryobiology **37**, 171–186 (1998)
336. A.A. Gage, J.G. Baust, Cryo Letters **23**, 69–78 (2002)
337. G. Gambassi, E. Cerbai, M. Pahor, M.C. Capograssi, P. Carbonin, A. Mugelli, Cardiovasc. Res. **28**, 391–399 (1994)
338. D.Y. Gao, S. Lin, P.F. Watson, L.K. Critser, Cryobilogy **32**, 270–284 (1995)
339. A.E. Garcia, G. Hummer, Proteins Struct. Funct. Genet. **38**, 261–272 (2000)
340. J.L. Garden, J. Richard, H. Guillou, Temperature of systems out of thermodynamic equilibrium. arXiv:cond-mat/0804.4456v1 [cond-mat.soft]
341. J. Gehl, Acta. Physiol. Scand. **177**, 437–447 (2003)
342. P.J.G. de Gennes, Rev. Mod. Phys. **57**, 827–863 (1985)
343. I.M. Ghobrial, T.E. Witzig, A.A. Adjei, CA Cancer J. Clin. **55**, 178–194 (2005)
344. A.J. Giegel, P. Collett, J. Food. Eng. **10**, 255–273 (1989)
345. J.A. Gilbert, P.J. Hill, J. Laybourn-Parry, Microbiology **150**, 171–180 (2004)
346. W. Gill, J. Fraser, D.C. Carter, Nature **219**, 410–413 (1968)
347. D.T. Gillespie, J. Comput. Phys. **22**, 403–434 (1976)
348. G.L. Gilliland, M. Tung, J. Ladner, J. Res. Natl. Inst. Stand. Technol. **101**, 309–320 (1996)
349. A. Gilmor, J. Liu, A.T. Peter, J.K. Critser, Biol. Reprod. **58**, 28–36 (1998)
350. J.A. Gilmore, J. Liu, E.J. Woods, A.T. Peter, J.K. Critser, Human Reprod. **15**, 335–343 (2000)
351. R.R. Gilpin, J. Colloid Interface Sci. **68**, 235–251 (1979)

352. N. Giovambattista, C.A. Angell, F. Sciortino, H.E. Stanley, Phys. Rev. Lett. **93**, 047801 (2004)
353. N. Giovambattista, P.J. Rossky, P.D. Debenedetti, Phys. Rev. E **73**, 041604 (2006)
354. N. Giovambattista, H.E. Stanley, F. Sciortino, Phys. Rev. E **72**, 031510 (2005)
355. N. Giovambattista, H.E. Stanley, F. Sciortino, Phys. Rev. Lett. **94**, 107803 (2005)
356. M.N. Giraud, C. Motta, D. Boucher, G. Grizard, Human Reprod. **15**, 2160–2164 (2000)
357. A. Glättli, X. Daura, W.F. van Gunsteren J. Chem. Phys. **116**, 9811–9828 (2002)
358. A. Glättli, X. Daura, W.F. van Gunsteren J. Comput. Chem. **24**, 1087–1096 (2003)
359. N. Goldman, C. Leforestier, R.J. Saykally, Phil. Trans. R. Soc. A **363**, 493–508 (2005)
360. A. Goltsev, A. Kozlova, Y. Dubrava, T. Ostankov, M. Sirous, Cell Preserv. Technol. **5**, 33–40 (2007)
361. I.A.M. de Graaf, A.L. Draaisma, O. Schoeman, G.M. Fahy, G.M.M. Groothuis, H.J. Koster, Cryobiology **54**, 1–12 (2007)
362. I.A.M. de Graaf, H.J. Koster, Toxicol. in Vitro **17**, 1–17 (2003)
363. S.P. Graether, M.J. Kulper, S.M. Gagné, V.K. Walker, Z. Jia, B.D. Sykes, P.L. Davies, Nature **406**, 325–328 (2000)
364. L.A. Graham, P.L. Davies, Science **310**, 461 (2005)
365. L.A. Graham, Y.C. Liow, V.K. Walker, P.L. Davies, Nature **388**, 727–728 (1977)
366. L. Gránásy, J. Mol. Struct. **485/486**, 523–526 (1999)
367. L. Gránásy, T. Pusztai, T. Börzsönyi, G. Tóth, G. Tegze, J. Mater. Res. **21**, 309–319 (2006)
368. L. Gránásy, T. Pusztai, T. Börzsönyi, G. Tóth, G. Tegze, J.A. Warren, J.F. Douglas, Philos. Mag. **86**, 3757–3778 (2006)
369. L. Gránásy, T. Pusztai, T. Börzsönyi, G.I. Tóth, G. Tegze, J.A. Warren, J.F. Douglas, Phil. Mag. **86**, 3757–3778 (2006)
370. J.J. Gray, Curr. Opin. Struct. Biol. **14** (2004)
371. P.J. Green, R. Sibson, Comput. J. **21**, 168–173 (1977)
372. M. Griebel, W. Merz, T. Neunhoeffer, Comput. Visual. Sci. **1**, 201–219 (1999)
373. M. Griffith, M. Antikainen, W.C. Hon, K. Pihakaski-Maunsbach, X.M. Yu, J.U. Chun, D.S.C. Yang, Plant Physiol. **100**, 327–332 (1997)
374. M. Griffith, K.W. Ewart, Biotech. Adv. **13**, 375–402 (1995)
375. M. Griffith, C. Lumb, S.B. Wiseman, M. Wisniewski, R.W. Johnson, A.G. Marangoni, Plant Physiol. **138**, 330–340 (2005)
376. M. Griffith, M.W. Yaish, TIPS **9**, 399–405 (2004)
377. S.V. Grinstein, O.A. Kost, Adv. Biol. Chem. (in Russian) **41**, 77–104 (2001)
378. A.Y. Grosberg, A.R. Khokhlov, Sov. Phys. Usp. **29**, 797–799 (1986)
379. D.C. Gross, E.L. Proebsting, H. MacCrindle-Zimmerman, Plant Physiol. **88**, 915–922 (1988)
380. O.I. Gudzenko, A.I. Lapshin, A.V. Kosoturov, A.M. Trokhan, J. Technol. Phys. (in Russian) **55**, 612–614 (1985)
381. J. Güémez, C. Fiolhais, M. Fiolhais, Eur. J. Phys. **23**, 83–91 (2002)
382. J.F. Guenther, S. Seki, F.W. Kleinhans, K. Edashige, D.M. Roberts, P. Mazur, Cryobiology **52**, 401–416 (2006)

383. P. Guo, S.D. Hillyard, B.M. Fu, Am. J. Physiol. Regul. Integr. Comp. Physiol. **285**, R1384–R1394 (2003)
384. G. ter Haar, Prog. Biophys. Mol. Biol. **93**, 111–129 (2007)
385. B. Halle, Proc. Natl. Acad. Sci. USA **101**, 4793–4798 (2004)
386. B. Halle, Phil. Trans. R. Soc. Lond. B **359**, 1207–1224 (2004)
387. B. Han, J.C. Bishof, Cryobiology **48**, 8–21 (2004)
388. B. Han, J.C. Bishof, J. Biomech. Eng. **126**, 196–203 (2004)
389. B. Han, J.H. Choi, J.A. Dantzig, J.C. Bishof, Cryobiology **52**, 146–151 (2004)
390. D.W. Han, S.H. Hyon, J.C. Park, K.D. Park, Y.H. Park, H.K. Park, Biomed. Mater. **1**, R18–R29 (2006)
391. T. Hansson, C. Oostenbrink, W.F. van Gunsteren, Curr. Opin Struct. Biol. **12**, 190–196 (2002)
392. Y. Hanyu, M. Ichikawa, G. Matoumoto, J. Microsc. **165**, 225–235 (1992)
393. J. Harada, M. Dohi, T. Mogami, K. Fukuda, K. Miki, N.F.K. Kishimoto, T. Simizu, K. Miyasaka, Radiat. Med. **19**, 291–296 (2001)
394. J.L. Harden, J.L. MacKintosh, P.D. Olmstead, Phys. Rev. E **72**, 011903 (2005)
395. S.M. Harrison, D.M. Bers, J. Gen. Physiol. **93**, 411–428 (1989)
396. L. Hatton, IEEE Comp. Sci. Eng. **4**, 27–38 (1997)
397. S. Havlin, S.V. Buldyrev, A.L. Goldberger, R.N. Mantegna, S.M. Ossadnik, C.K. Peng, M. Simons, H.E. Stanley, Chaos Solitons Fractals **6**, 171–201 (1995)
398. M. Heinlein, S. Mukherjee, O. Richmond, Acta Mechanica **59**, 59–81 (1986)
399. R. Heller, Techn. Cancer Res. Treatment **1**, 317–318 (2002)
400. R.H. Henchman, J.A. McCammon, Protein Sci. **11**, 2080–2090 (2002)
401. K. Heremans, Brazil. J. Med. Biol. Res. **38**, 1157–1165 (2005)
402. U. Heugen, G. Schwaab, E.M. Brúndermann, M. Heyden, X. Yu, D.M. Leitner, M. Havenith, Proc. Natl. Acad. Sci. USA **103**, 12301–12306 (2006)
403. S.J. Hiemstra, T. van der Lende, H. Woelders, in *The Role of Biotechnology for the Characterisation and Conservation of Crop, Forestry, Animal and Fishery Genetic Resources*, Int. workshop, Turin, 25–35 (2005)
404. M.J. Higgins, M. Polcik, T. Fukuma, J. Sader, Y. Nakayama, S. Jarvis, Biophys. J. **91**, 2532–2542 (2006)
405. W.B. Hillig, J. Crystal Growth **183**, 463–468 (1998)
406. M. Hilt, W. Pesch, W. Zimmermann, NIC Series **20**, 453–463 (2003)
407. D.H. Hincha, Phil. Trans. R. Soc. Lond. B **357**, 909–916 (2002)
408. J.P. Hindmarsh, A.B. Russel, X.D. Chen, Int. J. Heat Mass Transfer **46**, 1199–1213 (2003)
409. A. Hines-Peralta, Y. Hollander, S. Solazzo, C. Horkan, J. Vasc. Interv. Radiol. **15**, 1111–1120 (2004)
410. R. Hochmuth, P. Deuflhard, Multiscale analysis for the bio-heat transfer equation. ZIB–Report 03–08 (2003)
411. N.E. Hoffmann, J.C. Bishof, Urology **60**(Suppl 2A), 40–49 (2002)
412. N.E. Hoffmann, J.E. Coad, C.S. Huot, D.J. Swanlund, J.C. Bischof, Cryobiology **41**, 59–68 (2001)
413. P.C. Hohenberg, B.I. Galperin, Rev. Mod. Phys. **49**, 435–479 (1977)
414. G. Holmes, D. Snyder, in *Proc. 2nd Int. Conf.,* Miami*, Numerical Grid Generation in CFD*, (1998) pp. 643–652
415. T. Hölttä, Thesis, University of Helsinki, 2005

416. J. Hong, B. Rubinsky, Cryobiology **31**, 109–120 (1994)
417. T. Hoshino, A.M. Tronsmo, N. Matsumoto, T. Araki, F. Georges, T. Goda, S. Ohgiya, K. Ishizaki, Proc. NIPR Symp. Polar. Biol. **11**, 112–118 (1998)
418. H. Hu, A. Argyropoulos, Modell. Simul. Mater. Sci. Eng. 4, 371–396 (1996)
419. C. Huang, J. Yan, Int. J. Heat Mass Transfer **38**, 3433–3441 (1995)
420. J. Huang, R.G. Holt, R.O. Cleveland, R.A. Roy, J. Acoust. Soc. Am. **116**, 2451–2458 (2004)
421. A. Hubel, J. Norman, T.B. Darr, Cryobiology **38**, 140–153 (1999)
422. M.A. Huges, M.A. Dunn, J. Exp. Bot. **47**, 291–305 (1996)
423. J.M.J. Huttunen, T. Huttunen, M. Malinen, J.P. Kaipio, Phys. Med. Biol. **51**, 1011–1032 (2006)
424. J.M. Hyman, Physica D **12**, 396–407 (1984)
425. N. Iitaka, T. Ebisuzaki, J. Phys. Condens. Matter **16**, S1171–S1176 (2004)
426. Intensity Modulated Radiation Therapy Collaborative Working Group. Int. J. Radiat. Oncol. Biol. Phys. **51**, 880–914 (2001)
427. T. Irdani, B. Carletti, L. Ambrogioni, P. Roversi, Cryobiology **52**, 319–322 (2006)
428. D. Irimia, O.M. Karlsson, Biophys. J. **82**, 1858–1868 (2002)
429. D. Irimia, O.M. Karlsson, Biophys. J. **88**, 647–660 (2005)
430. V. Isachenko, E. Isachenko, I.I. Katkov, M. Montag, S. Dessole, F. Nawroth, H. van der Ven, Biol. Reprod. **71**, 1167–1173 (2004)
431. H. Ishigo, B. Rubinsky, Cryobiology **31**, 483–500 (1994)
432. G.R. Ivanitskii, Phys. Usp. **49**, 1263 (2006)
433. A. Jackson, G. Colver, R.P.R. Dawber, *Cutaneous Cryosurgery: Principles and Clinical Practice*, 3rd edn, (Informa Healthcare, London, 2005)
434. K.A. Jackson, B. Chalmers, J. Appl. Phys. **29**, 1178–1181 (1958)
435. M. Jaeger, M. Carin, J. Comput. Phys. **179**, 704–735 (2002)
436. M. Jaeger, M. Carin, M. Medale, G. Tryggvason, Biophys. J. **77**, 1257–1267 (1999)
437. E.A. Jagla, Brazil. J. Phys. **34**, 17–23 (2004)
438. K.R. Jaglo-Ottosen, S.R. Gilmour, D.G. Zarka, O. Schabenberger, M.F. Thomashow, Science **280**, 104–106 (1998)
439. J. Jain, R. Paulson, Fertil. Steril. **86**, 1037–1046 (2006)
440. S.J. James, C. James, *Meat Refrigeration*. (Woodhead Publishing, Cambridge, 2002)
441. N.V. Jamieson, R. Sundberg, S. Lindell, J.H. Southard, F.O. Belzer, Cryobiology **25**, 300–310 (1988)
442. M. Janik, F.W. Kleinhans, M. Hageborn, Cryobiology **41**, 25–34 (2000)
443. W. Janke, Lect. Notes Phys. **716**, 207–260 (2007)
444. H. Jansson, J. Swenson, Eur. Phys. J. E **12**, s51–s54 (2003)
445. O.E. Jay, Ph.D. Thesis, Loughborough University, 2002
446. C.E. Jeffree, N.D. Reed, J.A.C. Smith, J.E. Dale, Planta **172**, 20–37 (1987)
447. M.O. Jensen, O.G. Mouritsen, Biophys. J. **90**, 2270–2284 (2006)
448. M.O. Jensen, U. Rïhlisberger, C. Rovira, Biophys. J. **89**, 1744–1759 (2005)
449. E. Jeremias, M.A. Bedaiwy, D. Nelson, C.V. Biscotti, T. Falcone, Fertil. Steril. **79**, 651–653 (2003)
450. L. Ji, MS Thesis, Florida State University, 2006
451. S.C. Jiang, N. Ma, H.J. Li, X.X. Zhang, Burns **28**, 713–717 (2002)
452. A. Jiao, X. Han, J.K. Critser, H. Ma, Cryobiology **52**, 386–392 (2006)

453. A. Jiao, R. Riegler, H. Ma, G.P. Petersen, J. Microfluidics Nanofluidics **1**, 227–233 (2005)
454. B. Joe, SIAM J. Sci. Comput **16**, 1292–1307 (1995)
455. W.L. Jorgensen, J. Chandrasekhar, J.D. Madura, R.W. Impey, M.L. Klein, J. Chem. Phys. **79**, 926–935 (1983)
456. A. Jorov, B.S. Zhorov, D.S.C. Yang, Protein Sci. **13**, 1524–1537 (2004)
457. M.A. Joslyn, in *Cryobiology*, ed. by H.T. Meryman (Academic Press, London, 1966), pp. 565–607
458. M. Junkun, T.J. Kelly, A. Zaim, K. Young, R.W. Keck, S. Selman, J. Jankun, Comput. Aid. Surg. **4**, 193–199 (1999)
459. A. Jussofie, M. Kirsch, H. de Groot, Free Radic. Biol. Med. **25**, 712–719 (1998)
460. U. Kaatze, Phys. Med. Biol. **35**, 1663–1681 (1990)
461. L. Kai, W. Yan, T. Hongwei, C. Guangju, T. Zhenhe, Front. Biol. China **2**, 180–183 (2007)
462. M. Kalff-Suske, J. Reproduktionsmed. Endokrinol. **4**, 92–93 (2007)
463. A. Kalra, S. Garde, G. Hummer, Proc. Natl. Acad. Sci. USA **100**, 10175–10180 (2003)
464. D. Kandra, M.S. Thesis, Bangalore University, 2004
465. H. Kanno, R.J. Speedy, C.A. Angell, Science **189**, 880–881 (1975)
466. R. de Kanter, P. Olinga, I. Hof, M. de Jager, W. Verwillegen, M. Sloof, H. Koster, D. Meijer, G. Groothuis, Xenobiotica **28**, 225–234 (1998)
467. J.W. Kanwisher, in *Cryobiology*, ed. by H.T. Meryman, (Academic Press, London, 1966), pp. 487–494
468. R. Karch, F. Neumann, M. Neumann, W. Schreiner, Comput. Biol. Med. **29**, 19–38 (1999)
469. M. Kargol, Cell. Mol. Biol. Lett. **7**, 983–993 (2002)
470. M. Kargol, A. Kargol, Gen. Physiol. Biophys. **22**, 51–68 (2003)
471. M. Kargol, A. Kargol, M. Przestalski, J. Siedlecki, M. Karpińska, M. Rogowski, Ann. Acad. Medicae Biol. **50**, 237–240 (2005)
472. J.O.M. Karlsson, Cryobiology **42**, 154–169 (2001)
473. J.O.M. Karlsson, Science **296**, 655–656 (2002)
474. J.O.M. Karlsson, M. Toner, in *Principles of Tissue Engineering*, ed. by R.P. Lanza, R. Langer, J.P. Vacanti, 2nd edn. (Academic Press, San Diego, CA, 2000), pp. 180–194
475. O.M. Karlsson, Cryobiology **48**, 357–361 (2004)
476. V.N. Karnaukhov, E.N. Gakhova, V.K. Uteshov (eds.), *Conservation of genetic resources* (in Russian) (Puschino Sci. Center, RAS, 1996)
477. I.I. Katkov, F. Levine, Cryobiology **49**, 62–82 (2004)
478. D. Katschinski, News Physiol. Sci. **19**, 11–15 (2004)
479. D.S. Kauzmann, W. Eisenberg, *The Structure and Properties of Water* (Oxford University Press, Oxford, 1969)
480. J.E. Kay, V. Tsemekhman, B. Larson, M. Baker, B. Swanson, Atmos. Chem. Phys. **3**, 1439–1443 (2003)
481. O. Kedem, A. Katchalsky, Biochim. Biophys. Acta **27**, 229–246 (1958)
482. S.M. Kelly, S.L. Tan, in *Proc. 4th World Congr. On Controversies in Obsterics, Gynecology & Infertility*, Berlin, 2003, pp. 40–49
483. W.L. Kerr, C.J. Clark, M.J. McCarthy, J.S. de Ropp, Scientia Horticulturae **69**, 169–179 (1997)
484. L. Kerrigan, ATCC Connection **26**, 3–4 (2006)

485. F.N. Keutsch, R.J. Saykally, Proc. Natl. Acad. Sci. USA **98**, 10,533–10,540 (2001)
486. P. Khairy, P. Chauvet, J. Lehmann, J. Lambert, L. Macle, J.F. Tanguay, M.G. Sirois, D. Santoianni, M. Dubuc, Circulation **107**, 2045–2050 (2003)
487. A.R.A. Khaled, K. Vafai, Int. J. Heat Mass Transfer **46**, 4989–5003 (2003)
488. A.A. Khan, J.F.V. Vincent, J. Texture Studies **27**, 143–157 (1996)
489. M.A.M. Khan, L. Ahrné, J.C. Oliveira, F.A.R. Oliveira, Food Bioproducts Process. **86**, 7–13 (2008)
490. D.P. Kharakoz, Adv. Biol. Chem. (in Russian) **41**, 333–364 (2001)
491. K. Kim, Z. Guo, Comput. Meth. Prog. Med. **86**, 112–123 (2007)
492. K.S. Kim, I.S. Davis, P.A. Macpherson, T.J. Pedley, A.E. Hill, Proc. R. Soc. A **461**, 273–296 (2005)
493. N. Kimizuka, T. Suzuki, J. Phys. Chem. **111**, 2268–2273 (2007)
494. N. Kimizuka, C. Viriyarattanasak, T. Suzuki, Cryobiology **56**, 80–87 (2008)
495. K. Kinosita, T.Y. Tsong, Nature **268**, 438–441 (1977)
496. S. Kirkpatrick, C.D. Gelatt, M.P. Vecchi, Science **220**, 671–680 (1953)
497. M.V. Kirov, J. Struct. Chem. (in Russian) **42**, 958–965 (2001)
498. M.V. Kirov, J. Struct. Chem. (in Russian) **43**, 851–859 (2002)
499. R.A. Klein, in *NIC Symposium 2006*, vol. 32, ed. by G. Münster, D. Wolf, M. Kremer (John von Neumann Institute for Computing, Jülich, 2006), pp. 65–74
500. F.W. Kleinhans, J.F. Guenther, D.M. Roberts, P. Mazur, Cryobiology **52**, 128–138 (2006)
501. C.A. Knight, L.D. Ansd, A.L.D.V. Oolman, Nature **308**, 295–296 (1984)
502. C.A. Knight, A. Wierzbicki, Crystal Growth Design **1**, 439–436 (2001)
503. M.C. Knight, Phil. Trans. R. Soc. Lond. B **357**, 871–875 (2002)
504. R. Kobayashi, J.A. Warren, W.C. Carter, Physica D **119**, 415–423 (1998)
505. A.I. Kolesnikov, J.M. Zanotti, C.K. Loong, P. Thiyagarajan, A.P. Moravsky, R.O. Loutfy, C.J. Burnham, Phys. Rev. Lett. **93**, 035,503 (2004)
506. M.C. Kolios, M.D. Sherar, J.W. Hunt, Phys. Med. Biol. **40**, 477–494 (1995)
507. M.C. Kolios, A.E. Worthington, D.W. Holdsworth, M.D. Sherar, J.W. Hunt, Phys. Med. Biol. **44**, 1479–1497 (1999)
508. M.C. Kolios, A.E. Worthington, M.D. Sherar, J.W. Hunt, Phys. Med. Biol. **43**, 3325–3340 (1998)
509. J. Konc, S. Cseh, E. Varga, R. Kriston, K. Kanyó, J. Reproduktionsmed. Endokrinol. **2**, 251–258 (2005)
510. T.V. Kondratiev, R. Wold, E. Aasum, T. Tveita, Cryobiology **56**, 15–21 (2008)
511. A.A. Konstas, M.A. Neimark, A.F. Laine, J. Pile-Spellman, J Appl. Physiol. **102**, 1329–1340 (2007)
512. C.S. Körber, S. Englich, G. Rau, J. Microsc. **161**, 313–325 (1990)
513. B. Korniski, T.B. Darr, A. Hubel, Cryobiology **38**, 339–352 (1999)
514. N.N. Korpan (ed.), *Atlas of Cryosurgery* (Springer, Berlin Heidelberg New York, 2001)
515. N.N. Korpan (ed.), *Basics of Cryosurgery.* (Springer, Berlin Heidelberg New York, 2001)
516. N.N. Korpan, J. Am. College of Surgeons **204**, 314–324 (2007)
517. C. Koshimoto, P. Mazur, Biol. Reprod. **66**, 1477–1484 (2002)
518. A. Kotte, G. van Leeuwen, J. de Bree, J. van der Koijk, H. Crezee, J. Lagendjik, Phys. Med. Biol. **41**, 865–884 (1996)

519. H.S. Kou, T.C. Shih, W.L. Lin, Phys. Med. Biol. **48**, 1577–1589 (2003)
520. T. Kozlowski, Cold Regions Sci. Technol. **38**, 93 (2004)
521. K.C. Kregel, J. Appl. Physiol. **92**, 2177–2186 (2002)
522. E. Kristiansen, S. Pedersen, H. Ramlov, K.E. Zachariassen, J. Comp. Physiol. **B 169**, 55–60 (1999)
523. C. Kroener, B. Luyet, Biodynamica **10**, 47–52 (1966)
524. L.V. Kruglyakova, V.F. Tishkin, A.Y. Filatov, Math. Modeling (in Russian) **10**, 93–116 (1998)
525. T. Kücük, I. Baser, Eur. Clinics Obstet. Gynecol. **3**, 97–102 (2007)
526. E.G. Kuflic, J. Amer. Acad. Dermatol. **31**, 925–944 (1994)
527. P. Kumar, S.V. Buldyrev, S.R. Becker, P.H. Poole, F.W. Starr, H.E. Stanley, Proc. Natl. Acad. Sci. USA **104**, 9575–9579 (2007)
528. P. Kumar, S.V. Buldyrev, F.W. Starr, N. Giovambattista, H.E. Stanley, Phys. Rev. E **72**, 051503 (2005)
529. P. Kumar, F.W. Starr, S.V. Buldyrev, H.E. Stanley, Phys. Rev. E **75**, 011,202 (2007)
530. P.B.S. Kumar, G. Gompper, R. Lipowsky, Phys. Rev. E **60**, 4610–4618 (1999)
531. P.J. Kundrotas, A. Karshikoff, Protein Sci. **11**, 1681–1686 (2002)
532. I.F.W. Kuo, C.J. Mundy, M.J. McGraph, J.I. Siepmann, M.S. VandeVondele, J. Hutter, B. Chen, M.L. Klein, F. Mohamed, M. Krack, M. Parrinello, J. Phys. Chem. **108**, 12990–12998 (2004)
533. H. Kusuoka, Y. Ikoma, S. Futaki, H. Suga, A. Kitabatake, T. Kamada, M. Inoue, Am. J. Physiol. **261**, H1005–H1010 (1991)
534. R.M. Lamaita, E.A. Bambirra, R.S. das Graças, M. Camargos, A.L. Silva-Filho, F.M. Reis, A.F. Camargos, J. Assist. Reprod. Gen. **22**, 105–106 (2005)
535. T.R. Larson, D.W. Robertson, A. Corica, D.G. Botswick, Urology **55**, 547–552 (2000)
536. P.C. Lauterbur, All science is interdisciplinary – from magnetic moments to molecules to men. http://nobelprize.org/nobel-prizes/medicine/laureates/2003/lauterbur-lecture.pdf (2003)
537. J.R. Layne, A.L. Jones, J. Exp. Zool. **290**, 1–5 (2001)
538. J.R. Layne, D.K. Kuharski, Environ. Entomol. **30**, 12–16 (2000)
539. J.R. Layne, R.E. Lee, Climate Res. **5**, 53–59 (1995)
540. T. Lazaridis, M. Karplus, J. Chem. Phys. **105**, 4294–4316 (1996)
541. P. Le Pivert, in *Handbook of Cryosurgery*, ed. by R. Ablin (Dekker, New York, 1980), pp. 15–68
542. B.W. Lee, R. Faller, A.K. Sum, I. Vattulainen, M. Patra, M. Karttunen, Structural effects of small molecules on phospholipid bilayers investigated by molecular simulations. ArXiv:physics/0407083 [physics.bio-ph]
543. R.E. Lee, J.P. Costanzo, Annu. Rev. Physiol. **60**, 55–72 (1998)
544. R.E. Lee, J.J. McGrath, R.T. Morason, R.M. Taddeo, J. Insect Physiol. **39**, 445–450 (1993)
545. G.M.J. van Leeuwen, J.J.W. Lagendijk, B.J.A.M.V. Leersum, A.P.M. Zwamborn, S.N. Hornsleth, A.N.T.J. Kotte, Phys. Med. Biol. **44**, 2367–2379 (1999)
546. G.M.J.V. Leeuwen, A.N.T. Kotte, J. de Bree, J.F.V. der Koijk, H. Crezee, J.J.W. Lagendjik, Phys. Med. Biol. **42**, 1451–1460 (1997)
547. S.P. Leibo, J.J. McGrath, E.G. Cravalho, Cryobiology **15**, 257–271 (1978)

548. S.P. Leibo, H.M. Picton, R.G. Godsen, in *Current Practicies and Controversies in Assisted Reproduction*, ed. by E. Vayena, P.J. Rowe, P.D. Griffin (World Health Organization, Geneva, 2002), pp. 152–165
549. T.G. Leighton, Prog. Biophys. Mol. Biol. **93**, 280–294 (2007)
550. A.P. Leis, M. Beck, M. Gruska, C. Best, R. Hegerl, W. Baumeister, J.W. Leis, IEEE Signal Proc. Magazine **95**, 95–103 (2006)
551. T. Lenné, G. Bryany, K.L. Koster, R. Holcomb, *Cryo 2006*, Abstract Book, (Hamburg, 2006), p. 136
552. A. Lerbret, P. Bordat, F. Affouard, M. Descamps, F. Migliardo, How homogeneous are the trehalose, maltose and sucrose water solutions ? An insight from Molecular Dynamics simulations. ArXiv:cond-mat/0503579 [cond-mat.other]
553. E.I. Levin, A.I. Zhmakin, Lect. Notes Comput. Sci., **1156**, 272–277 (1996)
554. R.L. Levin, E.G. Cravalho, C.G. Higgins, J. Theor. Biol. **71**, 225–254 (1978)
555. M. Levitt, M. Hirshberg, R. Sharon, K.E. Laidig, V. Daggett, J. Phys. Chem. B **25**, 5051–5061 (1997)
556. M. Levitt, B.H. Park, Structure **1**, 223–226 (1993)
557. Y. Levy, J.N. Onuchic, Annu. Rev. Biophys. Biomol. Struct. **35**, 389–415 (2006)
558. G. Li, J. Saenz, R.A. Godke, R.V. Devireddy, Reproduction **131**, 875–886 (2006)
559. J. Li, M. Izquierdo, T.C. Lee, Int. J. Food Sci. Technol. **32**, 41–49 (1997)
560. N. Li, C.A. Andorfer, J.G. Duman, J. Exp. Biol. **201**, 2243–2251 (1998)
561. X. Li, S.A. Hassan, E.L. Mehler, Proteins **60**, 464–484 (2005)
562. J. Liebermann, F. Nawroth, V. Isachenko, E. Isachenko, G. Rahimi, M.J. Tucker, Biol. Reprod. **67**, 1671–1680 (2002)
563. I.M. Lifshits, A.Y. Grossberg, A.R. Khokhlov, Sov. Phys. Usp. **22**, 123–142 (1979)
564. T.H. Lilley, Phil. Trans. R. Soc. London B **359**, 1321–1322 (2004)
565. P.J. Lillford, C.B. Holt, Phil. Trans. R. Soc. Lond. B **357**, 945–951 (2002)
566. T.T. Lin, K. Lung, Cryobiology **32**, 566 (1995)
567. G. Ling, Physiol. Chem. Phys. Med. NMR **36**, 1–19 (2004)
568. Y.C. Liou, A. Tocilj, P.L. Davies, Z. Jia, Nature **406**, 322–324 (2000)
569. G. Lipp, C. Körber, J. Crystal Growth **130**, 475–489 (1993)
570. G. Lipp, C. Körber, G. Rau, J. Crystal Growth **99**, 206–210 (1990)
571. B. Liu, L.C.H. Wang, D.D. Belke, Cell Calcium **12**, 11–18 (1991)
572. B.L. Liu, J. McGrath, L. McCabe, M. Baumann, African J. Biotechnol. **5**, 2014–2019 (2006)
573. J. Liu, W. Jia, H. Vu, G. Aguilar, in *Proc. 9th Ann. Conf. on Liquid Atomization and Spray Systems*, Toronto (2006)
574. J. Liu, E.J. Woods, Y. Agca, E.S. Critser, J.K. Critser, Biol. Reprod. **63**, 1303–1312 (2000)
575. J. Liu, L.X. Xu, IEEE Trans. Biomed. Eng. **46**, 1037–1043 (1999)
576. J. Liu, Y. Zhou, T. Yu, L. Gui, Z. Deng, Y. Lv, Min. Invas. Ther. Allied Technol. **13**, 47–57 (2004)
577. J. Liu, J.K. Zhu, Science **280**, 1943–1945 (1998)
578. Z. Liu, K. Muldrew, R.G. Wan, J.W. Elliot, Phys. Rev. E **67**, 061602-1–8 (2003)
579. Z. Liu, K. Muldrew, R.G. Wan, J.W. Elliot, Phys. Rev. E **69**, 021611-1–8 (2004)

580. Z. Liu, R.G. Wan, K. Muldrew, S. Sawchuk, J. Rewcastle, Finite Elem. Anal. Design **40**, 1641–1663 (2004)
581. J. Lodge, M. Baker, J. Pierrard, J. Chem. Phys. **24**, 716–719 (1956)
582. T. Loerting, N. Giovambattista, J. Phys. Condens Matter **18**, R919–R979 (2006)
583. R. Lohner, Eng. Comput. **12**, 86–210 (1996)
584. L.G. Loitsanskii, *Mechanics of Gases and Liquids* (in Russian), 3rd edn. (Nauka, Moscow, 1970)
585. T.V. Lokotosh, N.P. Malomuzh, V.L. Zacharchenko, J. Struct. Chem. (in Russian) **44**, 1085–1094 (2003)
586. R.M. Love, in *Cryobiology*, ed. by H.T. Meryman (Academic Press, London, 1966), pp. 317–405
587. J.S. Loveday, R.J. Nelmes, M. Guthrie, S.A. Belmonte, D.R. Allan, D.D. Klug, J.S. Tse, Y.P. Handa, Nature **410**, 451–457 (2001)
588. J.E. Lovelock, Biochim. Biophys. Acta **10**, 414–436 (1953)
589. J.E. Lovelock, M.W.H. Bishop, Nature **183**, 1394–1395 (1959)
590. D. Loyd, M. Karlsson, B.E. Erlandsson, J.G. Sjödin, P. Ask, Adv. Eng. Software **28**, 347–351 (1997)
591. L.K. Lozina-Lozinski, *Studies in Cryobiology.* (Coronet Books, Philadelphia, 1974)
592. I. Lubashevsky, V. Gafiychuk, Mathematical description of heat transfer in living tissue. ArXiv:adap-org/9911001
593. R. Lundheim, Phil. Trans. R. Soc. Lond. B **357**, 937–943 (2004)
594. D.C. Lung, T.F. Stahovich, Y. Rabin, Comp. Meth. Biomech. Biomed. Eng. **7**, 101–110 (2004)
595. V.Y. Lunin, P.V. Afonin, A.G. Urzhumtsev, Math. Biol. Bioinform. (in Russian) **1**, 17–26 (2006)
596. S.N. Luo, T.J. Ahrens, T. Cağin, A.W.A.G. Strachan III, D.C. Swift, Phys. Rev. B **68**, 134,206 (2003)
597. P. Lupetti, in *From Cells to Proteins: Imaging Nature across Dimensions* ed. by V. Evangelista, L. Barsanti, V. Passarelli, P. Gualtieri (Springer, Berlin Heidelberg New York, 2005), pp. 53–70
598. B.J. Luyet, Biodynamica **1**, 1–14 (1937)
599. B.J. Luyet, in *Cryobiology*, ed. by H.T. Meryman (Academic Press, London, 1966), pp. 115–138
600. B.J. Luyet, R. Hodapp, Proc. Soc. Exp. Biol. **39**, 433–434 (1938)
601. Y.G. Lv, Z.S. Deng, J. Liu, IEEE Trans. Nanobioscience **4**, 284–294 (2005)
602. A.K. Lyashenko, V.S. Dunyashev, J. Struct. Chem. (in Russian) **44**, 906–915 (2003)
603. A.E. Lyubarev, B.I. Kurganov, Adv. Biol. Chem. (in Russian) **40**, 43–84 (2000)
604. A.K. Hashido, M. Ikeguchi, Biophys. J. **93**, 373–385 (2007)
605. D.R. MacFarlane, M. Fragoulis, Phys. Chem. Glasses **27**, 228–234 (1986)
606. D.R. MacFarlane, J. Scheirer, S.I. Smedley, J. Phys. Chem. **90**, 2168–2173 (1986)
607. A. Machlenkin, O. Goldberger, B. Tirosh, A. Paz, I. Volovitz, E. Bar-Haim, S.H. Lee, E. Vadai, E. Tzehoval, L. Eisenbach, Clin. Cancer Res. **11**, 4955–4961 (2005)
608. A. Madan, R. Dehaan, D. Mudra, K. Carrol, E. Lecluyse, A. Parkinson, Drug Metabolism and Disposition **27**, 327–335 (1999)

609. H. Mader, J. Glaciol. **38**, 333–347 (1992)
610. A.C. Maggs, Phys. Rev. Lett. **97**, 197,802 (2006)
611. T. Mala, MD Thesis, University of Oslo, 2003
612. T. Mala, Minimally Invasive Therapy **15**, 9–17 (2006)
613. T. Mala, E. Samset, L. Aurdal, B. Edwin, I. Gladhaug, O. Soreide, Cryobiology **43**, 268–275 (2001)
614. G.G. Malenkov, J. Struct. Chem. (in Russian) **47**, S5–S35 (2006)
615. M. Malinen, T. Huttunen, J.P. Kaipio, Phys. Med. Biol. **48**, 745–762 (2003)
616. F. Mallamace, S.H. Chen, M. Broccio, C. Corsaro, V. Crupi, P. Baglioni, E. Fratini, C. Vannucci, H.E. Stanley, J. Chem. Phys. **127**, 045104 (2007)
617. J. Malmivuo, R. Plonsey, *Bioelectromagnetism – Principles and Applications of Bioelectric and Biomagnetic Fields* (Oxford University Press, New York, 1995)
618. A.B. Mamonov, R.D. Coalson, M.L. Zeidel, J.C. Mathai, J. Gen. Physiol. **130**, 111–116 (2007)
619. E. Mamontov, C.J. Burnham, S.H. Chen, A.P. Moravsky, C.K. Loong, N.R. de Souza, A.I. Kolesnikov, J. Chem. Phys. **124**, 194,703 (2006)
620. B.B. Mandal, in *Cryopreservation of Tropical Plant Germplasm – Current Research Progress and Applications*, ed. by F. Engelmann, H. Takagi (IPGRI, 2000), pp. 233–237
621. B.B. Mandal, K.P.S. Chandel, S. Diwvedi, Cryo-Letters **17**, 165–174 (1996)
622. P. Mansfield, Snap-shot MRI. http://nobelprize.org/nobel-prizes/medicine/laureates/2003/mansfield-lecture.pdf (2003)
623. L. Mao, H.S. Udaykumar, J.O.M. Karlsson, Int. J. Heat Mass Transfer **46**, 5123–5136 (2003)
624. R.C. Marcove, T.R. Miller, Surg. Clin. N. Am. **49**, 421–430 (1969)
625. R. Margesin, G. Neuner, K.B. Storey, Naturwissenschaften **94**, 77–99 (2007)
626. D. Marks, M.E. Tuckerman, J. Hutter, M. Parinello, Nature **397**, 601–604 (1999)
627. M.I. Marqués, J.M. Borreguero, H.E. Stanley, N.V. Dokholyan, Phys. Rev. Lett. **91**, 138,101 (2003)
628. A. Massip, Reprod. Domest. Animals **36**, 49–55 (2001)
629. K. Matsuda, T. Hibi, H. Kadowaki, H. Kataura, Y. Maniwa, Phys. Rev. E **74**, 073,415 (2006)
630. M. Matsumoto, S. Saito, I. Ohmine, Nature **416**, 409–413 (2002)
631. S. Matsumoto, M. Matsusita, T. Morita, H. Kamachi, S. Tsukiyama, Y. Furukawa, S. Koshida, Y. Tachibana, S. Nishimura, S. Todo, Cryobiology **52**, 90–98 (2006)
632. Y. Matsumoto, J.S. Allen, S. Yoshizawa, T. Ikeda, Y. Kaneko, Exp. Thermal Fluid Sci. **29**, 255 (2005)
633. B. Mayer, R. Oberbauer, News Physiol. Sci. **18**, 89–94 (2003)
634. E. Mayer, R. Pletzer, Nature **319**, 298–301 (1986)
635. P. Mazur, J. Gen. Physiol. **39**, 869–888 (1956)
636. P. Mazur, J. Gen. Physiol. **47**, 347–369 (1963)
637. P. Mazur, in *Cryobiology*, ed. by H.T. Meryman (Academic Press, London, 1966), pp. 213–315
638. P. Mazur, Am. J. Physiol. **247**, 125–142 (1984)
639. P. Mazur, Biophysical and biological factors determining the ability to achieve long-term cryobiological preservation. ORNL/CP - 95102 (1997)

640. P. Mazur, F.W. Kleinhans, Cryobiology **56**, 22–27 (2008)
641. P. Mazur, C. Koshimoto, Biol. Reprod. **66**, 1485–1490 (2002)
642. P. Mazur, I.L. Pinn, F.W. Kleinhans, Cryobiology **54**, 223–233 (2007)
643. P. Mazur, S. Seki, I.L. Pinn, F.W. Kleinhans, K. Edashige, Cryobiology **51**, 29–53 (2005)
644. M.G. Mazza, N. Giovambattista, H.E. Stanley, F.W. Starr, Phys. Rev. E **76**, 031203 (2007)
645. M.G. Mazza, N. Giovambattista, F.W. Starr, H.E. Stanley, Phys. Rev. Lett. **96**, 057803 (2006)
646. J.R. McIntosh, J. Cell Biol. **153**, F25–F32 (2001)
647. R. McIntosh, D. Nicastro, D. Mastronarde, Trends Cell Biol. **15**, 43–51 (2005)
648. J.M. McKenzie, I.C. Voss, D.I. Siegel, Adv. Wat. Res. **30**, 966–983 (2007)
649. S. Meairs, A. Alonso, Prog. Biophys. Mol. Biol. **93**, 354–362 (2007)
650. H.T. Meryman, in *Cryobiology*, ed. by H.T. Meryman (Academic Press, London, 1966), pp. 610–663
651. H.T. Meryman, in *Cryobiology*, ed. by H.T. Meryman (Academic Press, London, 1966), pp. 1–114
652. M.V. Mesquita, A.R. Vasconcellos, R. Luzzi, S. Mascarenhas, Brazil. J. Phys. **34**, 459–488 (2004)
653. N. Metropolis, A.W. Rosenbluth, M.N. Rosenbluth, A.H. Tellera, E. Teller, J. Chem. Phys **21**, 1087–1092 (1953)
654. M. M'Hamdi, A. Mo, Mater. Sci. Eng. A **413–414**, 105–108 (2005)
655. H.W. Michelmann, P. Nayudu, Cell Tissue Banking **7**, 135–141 (2006)
656. S.P. Mickan, J. Dordick, J. Munch, D. Abbott, X.C. Zhang, in *Proc. of SPIE*, vol. 4937, ed. by D. Nicolau, A. Lee, 2002, pp. 49–61
657. J. Milhaud, Biochim. Biophys. Acta **1663**, 19–51 (2004)
658. C. Millar, Ph.D. Thesis, Glasgow, 2003
659. C. Millar, A. Asenov, S. Roy, J. Comput. Theor. Nanoscience **2**, 1–12 (2005)
660. L.K. Miller, Comp. Biochem. Physiol. A **73**, 595–604 (1982)
661. V.K. Milovanov, *Principles of Artificial Insemination* (in Russian) (State Publishing House, Moscow, 1934)
662. P.V. Minorsky, Plant Cell Environ. **12**, 195–135 (1989)
663. L.M. Mir, M. Belehradek, C. Domenge, B. Liboniski, S. Orlowski, J. Belehradek, B. Schwaab, C. Paoletti, C. R. Acad. Sci. Ser. III **313**, 613–618 (1991)
664. L.M. Mir, B. Rubinsky, Br. J. Cancer **86**, 1658–1660 (2002)
665. O. Mishima, J. Chem. Phys. **123**, 154506 (2005)
666. O. Mishima, H.E. Stanley, Nature **396**, 329–335 (1998)
667. O. Mishima, Y. Suzuki, J. Chem. Phys. **115**, 4199–4202 (2001)
668. Y. Mohammed, J.F. Verhey, BioMed. Eng. Online **4**, 1–16 (2005)
669. G. Monaco, S. Falconi, W.A. Crichton, M. Mezouar, Phys. Rev. Lett. **90**, 255,701 (2003)
670. A.F. Monroy, R.S. Dhindsa, Plaant Cell **7**, 321–331 (1995)
671. M. Mont, T. Einhorn, P. Sponseller, D. Hungerford, J. Bone Joint Surg. **80B**, 56–62 (1998)
672. Y. Moore, P. Sofer, M. Ilovich, The science and technology behind cryosurgery. Technical notes, Galil Medical (2001)
673. A.J. Moreno, S.V. Buldyrev, E.L. Nave, F.S. Saika-Voivod, P. Tartaglia, E. Zaccarelli, Phys. Rev. Lett. **95**, 157802 (2005)

674. G.J. Morris, Human Reprod. **21**, 2075–2083 (2006)
675. G.J. Morris, E. Acton, S. Avery, Human Reprod. **14**, 1013–1021 (1999)
676. G.J. Morris, J.J. McGrath, Cryo-Letter **2**, 341–352 (1981)
677. J.M. Morris, M. Goodrich, E. Acton, F. Fonesca, Cryobiology **52**, 323–334 (2006)
678. V. Mouraviev, T.J. Polascik, Curr. Opin. Urol. **16**, 152–156 (2006)
679. O.G. Mouritsen, M. Bloom, J.H. Ipsen, L. Miao, M. Nielsen, J. Polson, J. Thewalt, H. Zhu, M.J. Zuckermann, NIC Series **23**, 347–374 (2004)
680. G.M. Mrevlishvili, Sov. Phys. Usp. **22**, 433–455 (1979)
681. J. Mugnano, R. Lee, R. Taylor, J. Exp. Biol. **199**, 465–471 (1996)
682. C. Muguruma, Y. Okamoto, M. Mikami, Internet El. J. Mol. Design **1**, 583–592 (2002)
683. P.K. Mukherjee, J. Bhattacharya, J. Chem. Phys. **126**, 024,901 (2007)
684. K. Muldrew, L.E. McGann, Biophys.J. **57**, 525–532 (1990)
685. K. Muldrew, L.E. McGann, Biophys.J. **66**, 532–541 (1994)
686. K. Muldrew, J. Rewcastle, B.J. Donnelly, J.C. Saliken, S. Liang, S. Goldie, M. Olson, R. Baissalov, G. Sandison, Cryobiology **42**, 182–189 (2001)
687. S.F. Mullen, Ph.D. Thesis, University of Missouri-Columbia, 2007
688. S.F. Mullen, Y. Agka, J.K. Critser, Cell Preserv. Technol. **2**, 145–155 (2004)
689. S.F. Mullen, J.K. Critser, in *Oncofertility. Fertility Preservation for Cancer Survivors*, ed. by T. Woodruff, K.A. Snyder (Springer, New York, US, 2007), pp. 83–109
690. S.F. Mullen, M. Rosenbaum, J.K. Critser, Cryobiology **54**, 281–289 (2007)
691. T. Müller-Reichert, H. Hohenebrg, E.T. O'Toole, K. Mcdonald, J. Microsc. **212**, 71–80 (2003)
692. W.W. Mullins, R.F. Sekerka, J. Appl. Phys. **35**, 444–451 (1964)
693. N. Murata, O. Ishizaki-Nishigawa, S. Higashi, H. Hayashi, Y. Tasaka, I. Nishida, Nature **356**, 710–713 (1992)
694. D.J. Murphy, J. Exp. Biol. **69**, 1–12 (1977)
695. H.M. Murray, C.L. Hew, K.R. Kao, G.L. Fletcher, Can. J. Zool. **80**, 110–119 (2002)
696. H. Nada, J.P.J.M. van der Eerden, J. Chem. Phys. **118**, 7401 (2003)
697. H. Nagashima, N. Kashiwasaki, R.J. Ashman, C.G. Grupen, M.B. Nottle, Nature **374**, 416 (1995)
698. H. Nagashima, N. Kashiwasaki, R.J. Ashman, C.G. Grupen, R.F. Seamark, M.B. Nottle, Theriogenelogy **41**, 113–118 (1994)
699. R. Nakamura, K. Tuncali, P.R. Morton, N. Hata, S.G. Silverman, R. Kikinis, F.A. Jolesz, G.P. Zientara, Lect. Notes Comput. Sci. **3217**, 542–550 (2004)
700. M. Nakasako, Cell Mol. Biol. **47**, 767–790 (2001)
701. M. Nakasako, Phil. Trans. R. Soc. Lond. A **359**, 1191–1206 (2004)
702. K. Nakashima, K. Yamaguchi-Shinozaki, Physiol. Plant. **126**, 62–71 (2006)
703. C.N. Nanev, Cryst. Res. Techn. **42**, 4–12 (2007)
704. D.V. Nanopoulos, Theory of brain function, quantum mechanics and superstrings. CERN-TH/95-128 (1995)
705. K.H. Nealson, P.G. Conrad, Phil. Trans. R. Soc. Lond. B **354**, 1923–1939 (1999)
706. J. Nedoma, J. Comput. Appl. Math **84**, 45–80 (1997)
707. G.W. Neilson, P.E. Mason, S. Ramos, D. Sullivan, Phil. Trans. R. Soc. Lond. A **359**, 1575–1591 (2001)

708. G.F. Nellis, S.A. Klein, F. Keppler, K. Fredrickson, Design data for optimization of cryosurgical probes ASHRAE 1246-TRP. http://sel.me.wisc.edu/student%20pages/fredrickson/website/ progressreport3.pdf
709. J.S. Nelson, T.E. Millner, B. Anvari, B.S. Tanelbaum, B.S. Kimel, L.O. Svaasand, S.L. Jacques, Acta Dermatol. **131**, 695–700 (1995)
710. D.T. Nguyen, M.E. Colvin, Y. Yeh, R.E. Feeney, W.H. Fink, Biopolymers **75**, 109–117 (2004)
711. D. Ni, H.J. Shi, Y.J. Yin, L.S. Niu, J. Biol. Phys. **32**, 369–381 (2006)
712. J. Nilsson, Ph.D. Thesis, Stockholm University, 2004
713. K. Nygård, M. Hakala, S. Manninen, A. Andrejczuk, M. Itou, Y. Sakurai, L. Pettersson, K. Hämäläinen, Phys.Rev. E **74**, 031503 (2006)
714. W.L. Oberkampf, T.G. Trucano, Prog. Aero. Sci. **38**, 209–272 (2002)
715. W.D. O'Brien, Prog. Biophys. Mol. Biol. **93**, 212–255 (2007)
716. J.T. Oden, IACM Express **12**, 12–15 (2002)
717. D. Ofengeim, A. Zhmakin, Lect. Notes Comput. Sci. **2657**, 3–12 (2003)
718. N. Ohno, N. Terada, S. Murata, R. Katoh, S. Ohno, J. Histochem. Cytochem. **53**, 55–62 (2005)
719. N. Okamoto, M. Oguni, Y. Sagawa, J. Phys. Condens. Matter **9**, 9187–9198 (1997)
720. K. Okawa, M. Sekine, M. Maeda, M. Tada, M. Abe, N. Matsushita, K. Nishio, H. Handa, J. Appl. Phys. **99**, 08H102 (2006)
721. A. Oleinikova, I. Brovchenko, N. Smolin, A. Krukau, A. Geiger, R. Winter, Phys. Rev. Lett. **95**, 247,802 (2005)
722. Y. Orief, K. Dafopoulos, Middle East Fert. Soc. J. **10**, 171–184 (2005)
723. R.D. Orpwood, Phys. Med. Biol. **26**, 555–575 (1981)
724. B.L. Orvar, V. Sangwan, F. Omann, R.S. Dhindsa, Plant J. **23**, 785–794 (2000)
725. S. Osher, P. Fedkiw, J. Comput. Phys. **169**, 463–502 (2001)
726. S. Osher, J.A. Sethian, J. Comput. Phys. **79**, 12–49 (1988)
727. D.M. Otten, B. Rubinsky, Physiol. Meas. **26**, 503–516 (2005)
728. D.W. Oxtoby, Annu. Rev. Mater. Res. **32**, 39–52 (2002)
729. D.W. Oxtoby, Phil. Trans. R. Soc. Lond. A **361**, 419–427 (2003)
730. R. Oyarzun, C. Viedma1, C. de Ignacio, Geology **28**, 935–938 (2000)
731. S. Özkavukcu, E. Erdemli, J. Ankara Med. School **24**, 187–196 (2002)
732. S. Pal, S. Balasubramanian, B. Bagchi, J. Chem. Phys. **120**, 1912–1920 (2004)
733. S.K. Pal, J. Peon, A.H. Zewail, Proc. Natl. Acad. Sci. USA **99**, 1763–1768 (2002)
734. M.E. Palumbo, J. Phys. Confer. Series **6**, 211–216 (2005)
735. O.O. Panasenko, M.V. Kim, N.B. Gusev, Adv. Biol. Chem. (in Russian) **43**, 59–98 (2003)
736. S.A. Pandit, D. Bostick, M.L. Berkowitz, J. Chem. Phys. **119**, 2199–2205 (2003)
737. D. Papadjopoulos, S. Hui, W.J. Vail, G. Poste, Biochim. Biophys. Acta **448**, 254–264 (1976)
738. S. Park, J.G. Saven, Proteins Struct. Funct. Bioinform. **60**, 450–463 (2005)
739. M. Pasenkiewicz-Gierula, K. Murzyn, T. Rog, C. Czaplewski, Acta Biochim. Polonica **47**, 601–611 (2000)
740. S.V. Patankar, *Numerical Heat Transfer and Fluid Flow* (Hemispher Publishing Corp., New York, 1980)

741. S.R. Payne, D. Sandford, A. Harris, O.A. Young, Meat Sci. **37**, 429–438 (1994)
742. S.R. Payne, O.A. Young, Meat Sci. **41**, 147–155 (1995)
743. R.S. Pearce, Plant Growth Regulat. **29**, 47–76 (1999)
744. R.S. Pearce, J.H.M. Willison, Planta **163**, 295–303 (1985)
745. D.E. Pegg, Phys. Med. Biol. **11**, 209–224 (1966)
746. D.E. Pegg, Cryo-Letters **4**, 259–268 (1983)
747. D.E. Pegg, Cryo-Letters **7**, 387–394 (1986)
748. D.E. Pegg, A.R. Harris, Phys. Med. Biol. **15**, 409–416 (1970)
749. D.E. Pegg, M.C. Wusteman, S. Boylan, Cryobiology **33**, 658–659 (1996)
750. H.H. Pennes, J. Appl. Physiol. **1**, 93–122; reprinted: Ibid, 1998, 85, 5–34 (1948)
751. R. Penrose, *Shadows of the Mind* (Oxford University Press, Oxford, 1994)
752. S.S.L. Peppin, M.G. Worster, J.S. Wettlaufer, Proc. Roy. Soc. A **463**, 723–733 (2007)
753. N. Pertaya, Y. Celik, C.L. DiPrinzio, J.S. Wettlaufer, P.L. Davies, I. Braslavsky, J. Phys. Condens. Matter **19**, 412101 (2007)
754. D. Petcu, D. Vizman, M. Paprzycki, Scalable Comput. Pract. Exp. **7**, 15–23 (2006)
755. A. Petersen, I. Heschel, G. Rau, B. Glasmacher, Biomed. Tech. **49**, 632–633 (2004)
756. A. Petersen, G. Rau, B. Glasmacher, Heat Mass Transfer **42**, 929–938 (2006)
757. A. Petersen, H. Schneider, G. Rau, B. Glasmacher, Cryobiology **53**, 248–257 (2006)
758. A. Petersen, H. Schneider, G. Rau, B. Glasmacher, Cryobiology **53**, 248–257 (2006)
759. F. Petrat, T. Li, N. Dehne, H. de Groot, U. Rauen, Life Sci. **79**, 1606–1615 (2006)
760. A.M. Petrunkina, J. Reproduktionsmed. Endokrinol. **4**, 78–91 (2007)
761. A.M. Petrunkina, E. Jebe, E. Topfer-Petersen, J. Cell Physiol. **204**, 508–521 (2005)
762. A.M. Petrunkina, G. Volker, K.F. Weitze, M. Beyerbach, E. Topfer-Petersen, D. Waberski, Theriogenology **63**, 2278–2299 (2005)
763. D.N. Petsev, B.R. Thomas, S.T. Yau, D. Tsekova, C. Nanev, W.W. Wilson, P.G. Vekilov, J. Cryst. Growth **232**, 21–29 (2001)
764. M. Petukhov, G. Rychkov, L. Firsov, L. Serrano, Protein Sci. **13**, 2120–2129 (2004)
765. R.T. Pfaff, Y. Agca, J. Liu, E.J. Woods, A.T. Peter, J.K. Critser, Biol. Reprod. **63**, 1294–1302 (2000)
766. R.T. Pfaff, J. Liu, D. Gao, T.K. Li, J.K. Critser, Mol. Human Reprod. **4**, 51–59 (1998)
767. D.C. Pham, S. Torquato, J. Appl. Phys. **94**, 6591 (2003)
768. L. Pham, R. Dahiya, B. Rubinsky, Cryobiology **38**, 169–175 (1999)
769. Q.T. Pham, in *Food Process Modelling*, ed. by L.M.M. Tijskens, M.L.A.T.A. Hertog, B.M. Nikolai (Woodhead Publishing, Cambridge, 2001), pp. 316–338
770. J.C. Phillips, R. Braun, W. Wang, J. Gumbart, E. Tajkhorshid, E. Villa, C. Chipot, R.D. Skeel, L. Kale, K. Schulten, J. Comput. Chem. **26**, 1781–1802 (2005)
771. B.M. Pikkula, J.H. Torres, J.W. Tunnell, B. Anvari, Lasers Surg. Med. **28**, 103–112 (2001)
772. D. Pinisetty, MS Thesis, Louisiana State University, 2005

773. H.M. Piper, B. Siegmund, Y.V. Ladilov, K.D. Schlüter, Basic Res. Cardiol. **88**, 471–482 (1993)
774. S. Pirzadeh, Unstructured viscous grid generation by advancing-layers method, AIAA-93-3453-CP, 420–434 (1993)
775. C. Plieth, J. Membr. Biol. **172**, 121–127 (1999)
776. C. Polge, A.U. Smith, A.S. Parkers, Nature **164**, 666–676 (1949)
777. R.D. Ponti, Indian Pacing Electrophysiol. J. **5**, 12–24 (2005)
778. P.H. Poole, T. Grande, F. Sciortino, H.E. Stanley, C.A. Angell, Comput. Mat. Sci. **4**, 373–382 (1995)
779. A. Powell, "Hot" ice could lead to medical device. Harvard University Gazette Online, 20 September 2007
780. S.L. Powell, Ph.D. Thesis, Loughborough University, 2002
781. T. Preusser, A. Weihusen, H.O. Peitgen, in *Proc. Simul. and Visual. (SimVis)*, Magdeburg 2005, pp. 259–268
782. G.G. Prokorov, (ed.), *Advances in Cryomedicine* (in Russian) (Nauka St. Petersburg, 2001)
783. J.L. Puglisi, R.A. Bassani, J.W. Bassani, J.N. Amin, D.M. Bers, Am. J. Physiol. **270**, H1772–H1778 (1996)
784. N.S. Pushkar, Y.A. Itkin, V.L. Bronstein, E.A. Gordiyenko, Y.V. Kozmin, Cryobiology **13**, 147–152 (1976)
785. N.S. Pushkar, M.I. Shrago, A.M. Belous, Y.V. Kalugin, *Cryoprotectors* (in Russian) (Naukova Dumka Kiev, 1978)
786. A.R. Denet, R. Vanbever, V. Preat, Adv. Drug Deliv. Res. **56**, 659–674 (2004)
787. D. Raabe, Modelling Simul. Mater. Sci. Eng. **15**, 39–63 (2007)
788. Y. Rabin, Cryo-Letters **21**, 163–170 (2000)
789. Y. Rabin, Cryobiology **46**(2), 109–120 (2003)
790. Y. Rabin, D.C. Lung, T.F. Stahovich, Techn. Cancer Res. Treatment **3**, 229–243 (2004)
791. Y. Rabin, B.Z. Maytal, Cryo-Letters **20**, 95–102 (1999)
792. Y. Rabin, J. Plitz, Annals Biomed. Eng. **33**, 1213–1228 (2005)
793. Y. Rabin, A. Shitzer, Cryobiology **33**, 82–92 (1996)
794. Y. Rabin, A. Shitzer, Trans. ASME **120**, 32–37 (1998)
795. Y. Rabin, T.F. Stahovich, Cryo-Letters **23**, 361–374 (2002)
796. Y. Rabin, T.F. Stahovich, Phys. Med. Biol. **48**, 619–632 (2003)
797. Y. Rabin, P. Steif, Cryobiology **33**, 276–290 (1996)
798. Y. Rabin, P. Steif, Trans. ASME **65**, 328–333 (1998)
799. Y. Rabin, P. Steif, Adv. Heat Mass Transfer Biotechnol. HTD **363**, 183–187 (1999)
800. Y. Rabin, P. Steif, Int. J. Solids Struct. **37**, 2363–2375 (2000)
801. Y. Rabin, M.J. Taylor, N. Wolmark, J. Biomech. Eng. **120**, 259–266 (1998)
802. A.L. Rabinovich, in *Proc. XIII All-Russian conf. Structure and Dynamics of Molecular Systems*, 2006, pp. 156–166
803. M.M. Radai, S. Abboud, B. Rubinsky, Cryobiology **38**, 51–59 (1999)
804. R. Radebaugh, in *Microscale Heat Transfer*, ed. by S. Kakaç, L.L. Vasiliev, Y. Bayazitoglu, Y. Yener (US Government, 2005), pp. 445–464
805. R. Radhakrishnan, B.L. Trout, Phys. Rev. Lett. **90**, 158,301 (2003)
806. R. Radhakrishnan, B.L. Trout, J. Am. Chem. Soc. **125**, 7743–7747 (2003)
807. R. Radhakrishnan, B.L. Trout, in *Handbook of Materials Modeling, Vol. 1: Methods and Models*, ed by S. Yip (Springer Berlin Heidelberg New York, 2005), pp. 1–14

808. M. Raff, Nature **396**, 119–122 (1998)
809. W.F. Rall, G.M. Fahy, Nature **313**, 573–577 (1985)
810. J. Ramsay, Phil. Trans. R. Soc. Lond B **248**, 279–314 (1964)
811. R.P. Rand, Phil. Trans. R. Soc. Lond. B **359**, 1277–1285 (2004)
812. J.C. Rasaiah, R.M. Lynden-Bell, Phil. Trans. R. Soc. Lond. A **359**, 1545–1574 (2001)
813. T.M. Raschke, M. Levitt, Proc. Natl. Acad. Sci. USA **102**, 6777–6782 (2005)
814. U. Rauen, H. de Groot, Cryobiology **56**, 88–92 (2008)
815. J. Rault, J. Non-Crystalline Solids **271**, 177–217 (2000)
816. U. Raviv, P. Laurat, J. Klein, Nature **413**, 51–54 (2001)
817. B.M. Reed, (ed.), *Plant Cryopreservation: A Practical Guide* (Springer, Berlin Heidelberg New York, 2007)
818. K.L. Reed, T.D. Brown, M.G. Conzemius, J. Biomech. **36**, 1317–1326 (2003)
819. A.R. Rees, M.J.E. Sternberg, *From Cells to Atoms: An Illustrated Introduction to Molecular Biology* (Blackwell, Oxford, 1984)
820. P. Reinhound, F.V. Iren, J.W. Kijne, in *Cryopreservation of Tropical Plant Germplasm – Current Research Progress and Applications*, ed. by F. Engelmann, H. Takagi (IPGRI, Rome, 2000), pp. 91–100
821. A.W. Rempel, M.G. Worster, J. Crystal Growth **223**, 420–432 (2001)
822. J.C. Rewcastle, G.A. Sandison, J.C. Saliken, J.G. McKinnon, B.J. Donnelly, Dynamic cryosurgery: creating a more potent iceball with the use of thermal waves. http://www.cryoforum.org/Archive/Instrmt/inst2.html
823. M.C. Rheistädter, T. Seydel, F. Demmel, Phys. Rev. E **71**, 061908 (2005)
824. B. Rinker, X.D. Cui, M.L. Cibull, B. Fink, D.Y. Gao, H.C. Vasconez, HAND **3**, 17–23 (2008)
825. P.J. Roach, *Verification and Validation in Computational Science and Engineering* (Hermosa Publishers, Albuquerque, New Mexico, 1998)
826. C.P. Robert, G. Casella, *Monte Carlo Statistical Methods* (Springer-Verlag, New York, 2004)
827. C.H. Robinson, New Phytologist **151**, 341–353 (2001)
828. M.P. Robinson, M.C. Wusteman, L. Wang, D.E. Pegg, Phys. Med. Biol. **47**, 2311–2325 (2002)
829. V. Robles, V. Barbosa, M.P. Herráez, S. Martinez-Piramo, M.L. Cancela, Theriogenology **68**, 284–289 (2007)
830. F.A. Rodrigues, H.R.B. Orlande, G.S. Dulikravich, Math. Comput. Simul. **66**, 409–424 (2004)
831. R. Romero-Méndez, K. Chu, H. Vu, W. Franko, G. Aguilar, in *Proc. HT2005, 2005 ASME Summer Heat Transfer Conf.*, San Francisco, pp. 1–7 (2005)
832. R. Romero-Méndez, W. Franko, G. Aguilar, Phys. Med. Biol. **52**, 463–468 (2007)
833. G.D. Rose, R. Wolfenden, Ann. Rev. Biophys. Biomol. Struct. **22**, 381–415 (1993)
834. M.R. Rossi, Y. Rabin, Phys. Med. Biol. **52**, 4553–4567 (2007)
835. M.R. Rossi, D. Tanaka, K. Shimada, Y. Rabin, Comput. Meth. Prog. Biomed. **85**, 41–50 (2007)
836. P.F. Roversi, E. Cosi, T. Irdani, Cryobiology **56**, 1–7 (2008)
837. J.A. Ruane, E. Sonnio, (Eds.) *The Role of Biotechnology in Exploring and Protecting Agricultural Genetic Resources* (Food and Agriculture Organization of the UN, Rome), 187 pp. (2006)

838. B. Rubinsky, Annu. Rev. Biomed. Eng. **2**, 157–187 (2000)
839. B. Rubinsky, Heart Failure Rev. **8**, 277–284 (2003)
840. B. Rubinsky, C.J. Lee, J. Bastacky, J. Onik, Cryobiology **27**, 85–97 (1987)
841. B. Rubinsky, G. Onik, P. Mikus, Techn. Cancer Res. Treatment **6**, 1–12 (2007)
842. B. Rubinsky, D.E. Pegg, Proc. Roy. Soc. Lond. B **234**, 343–358 (1988)
843. O.V. Rudenko, Phys. Usp. **50**, 359–367 (2007)
844. A.S. Rudolph, J.H. Crowe, L.S. Crowe, Arch. Biochem. Biophys. **245**, 134–143 (1986)
845. J. Rui, K.N. Tatsutani, R. Dahiya, B. Rubinsky, Breast Cancer Res. Treat. **53**, 185–192 (1999)
846. D. Russo, G. Hura, T. Head-Gordon, Biophys. J. **86**, 1852–1862 (2004)
847. J. Rutlant, A.C. Pommer, S.A. Meyers, J. Androl. **24**, 534–541 (2003)
848. Y.E. Ryabov, A. Puzenko, Y. Feldman, Phys. Rev. B **69**, 014204 (2004)
849. A. Dinnyes, Y. Dai, S. Jiang, X. Yang, Theriogenology **52**, 215 (2000)
850. W. van Saarloos, Phys. Rep. **386**, 29–222 (2003)
851. M.S. Sabel, M.A. Nehs, G. Su, K.P. Lowler, J.L. Ferrara, A.E. Cheng, Breast Cancer Res. Treat. **90**, 97–104 (2005)
852. A. Sakai, Nature **185**, 393–394 (1960)
853. A. Sakai, in *Cryopreservation of Tropical Plant Germplasm – Current Research Progress and Applications*, ed. by F. Engelmann, H. Takagi (IPGRI, Rome, 2000), pp. 1–7
854. J.C. Saliken, B.J. Donnelly, J.C. Rewcastle, Urology **60**(Suppl 2A), 26–33 (2002)
855. L. Salinas-Flores, S.L. Adams, M.H. Lim, Cryobiology **56**, 43–52 (2008)
856. L. Salinas-Flores, S.L. Adams, D.A. Wharton, M.F. Downes, M.H. Lim, Cryobiology **56**, 28–35 (2008)
857. R.W. Salt, Nature **184**, 1426 (1959)
858. R.W. Salt, Nature **193**, 1207–1208 (1962)
859. E. Samset, T. Mala, B. Edwin, I. Gladhaug, O. Soreide, E. Fosse, Magn. Reson. Imaging **19**, 715–721 (2001)
860. K.Y. Sanbonmatsu, C.S. Tung, J. Struct. Biol. **157**, 470–480 (2007)
861. G.A. Sandison, Urology **60**(Suppl 2A), 50–55 (2002)
862. V. Sangwan, I. Foulds, J. Sinh, R.S. Dhindsa, Plant J. **27**, 1–12 (2001)
863. R.M. de Santos, M.H. Barreta, M. Frajblat, D.C. Cucco, J.C. Mezzaliza, S. Bunn, F.B. Cruz, A.D. Viera, A. Mezzaliza, Ciêcia Rural **36**, 1501–1506 (2006)
864. P.D. Sanz, C. de Elvira, M. Martino, N. Zaritzky, L. Otero, J.A. Carrasco, Meat Sci. **52**, 275–278 (1999)
865. S.M. Saparov, D. Kozono, U. Rothe, P. Agre, P. Pohl, J. Biol. Chem. **276**, 31515–31520 (2001)
866. G.N. Sarkisov, Phys. Usp. **49**, 809–820 (2006)
867. B. Sawaf, M. Özisik, Y. Jarny, Int. J. Heat Mass Trqnsfer **38**, 3005–3010 (1995)
868. A. Scala, F.W. Starr, E.L. Nave, H.E. Stanley, F. Sciortino, Phys. Rev. E **62**, 8016 (2000)
869. A.T. Schäfer, J.D. Kauffmann, Forensic Sci. Intern. **102**, 149–158 (1999)
870. T. Schlick, R.D. Skeel, A.T. Brunger, L.V. Kalé, J.A. Board, J. Hermans, K. Schulten, J. Comput. Phys. **151**, 9–48 (1999)
871. J.W.P. Schmelzer, E.D. Zanotto, I. Avramov, V.M. Fokin, J. Non-Crystalline Solids **352**, 434–443 (2006)

872. F. Schmid, D. Dúchs, O. Lenz, NIC Series **23**, 323–346 (2004)
873. G.W. Schmid-Schöbein, K.R. Diller, Ann. Biomed. Eng. **33**, 1136–1141 (2005)
874. J.D. Schmidt, J. Doyle, S. Larison, CA Cancer J. Clin. **48**, 239–253 (1998)
875. U. Schnider, P. Mazur, Cryobiology **24**, 17–41 (1987)
876. H. Schoof, L. Bruns, A. Fisher, I. Heschel, G. Rau, J. Cryst. Growth **209**, 122–129 (2000)
877. F. Sciortino, A. Geiger, H.E. Stanley, Nature **354**, 218–221 (1992)
878. F. Sciortino, E.L. Nave, A. Scala, H.E. Stanley, F.W. Starr, Eur. Phys. J. E **9**, 233–237 (2002)
879. K. Scott, J.P. Acker, Cell Preserv. Technol. **1**, 227 (2003)
880. K.L. Scott, J. Lecak, J.P. Acker, Transfusion Med. Rev. **19**, 127–142 (2005)
881. J.A. Searles, J.F. Carpenter, T.W. Randolph, J. Pharm. Sci. **90**, 860–871 (2001)
882. B.I. Sedunov, D.A. Frank-Kamenetskii, Sov. Phys. Usp. **7**, 1066–1071 (1963)
883. M. Segino, M. Ikeda, F. Hirahara, K. Sato, Reproduction **130**, 187–192 (2005)
884. J.K. Seifert, C.D. Gerharz, F. Mattes, F. Nassir, K. Fachinger, C. Beil, T. Jungingera, Cryobiology **47**, 214–226 (2003)
885. U. Seifert, Adv. Phys. **46**, 13–137 (1997)
886. S. Senapati, M.L. Berkowitz, J. Chem. Phys. **118**, 1937–1944 (2003)
887. B.M. Seo, M. Miura, W. Sonoyama, C. Coppe, R. Stanyon, S. Shi, J. Dent. Res. **84**, 907–912 (2005)
888. I.N. Serdyuk, Adv. Biol. Chem. (in Russian) **42**, 3–28 (2002)
889. V.V. Shafranov, E.N. Borkhunova, N.G. Korotkii, V.A. Vissarionov, A.G. Stenko, *Keloid Scars: Etiology, Clinical, Morphological, Physical Diagnostics and RF-Cryo Therapy* (in Russian) (CPR Delovaya kniga, 2003)
890. K.B. Shaitan, S.S. Saraikin, Molecular Dynamics Method. http://www.moldyn.ru/library/md/default.htm (1999)
891. A.N. Shalygin, K.A. Krotov, Phys. Usp. **33**, 541–553 (1990)
892. B.C. Shanks, D.M. Wulf, R.J. Maddock, J. Anim. Sci. **80**, 2122–2125 (2002)
893. J.M. Shaw, G.M. Jones, Human Reprod. Update **9**, 583–605 (2003)
894. M.L. Shepard, C.S. Goldston, F.H. Cocks, Cryobiology **13**, 9–23 (1976)
895. M.S. Shephard, M.K. Georges, Int. J Num. Meth. Eng. **32**, 709–749 (1991)
896. P. Sherwood, QM/MM methods. http://www.cfs.dl.ac.uk/tutorials/chemshell-workshop/ index.htm (2003)
897. T. Shi, R.H. Reeves, D.A. Gilinsky, E.I. Friedmann, Microbiol. Ecol. **33**, 169–179 (1997)
898. X. Shi, A.K. Datta, S. Mukherjee, J. Thermal Stresses **22**, 275–292 (1999)
899. A.A. Shibkov, Dr. Sci. Thesis, Belgorod State University, 2006
900. A.A. Shibkov, Y.I. Golovin, M.A. Zheltov, A.A. Korolev, A.A. Leonov, Physica A **319**, 65–79 (2003)
901. A.A. Shibkov, Y.I. Golovin, M.A. Zheltov, A.A. Korolev, A.A. Vlasov, Crysyallogr. Rep. **46**, 496–502 (2001)
902. A.A. Shibkov, M.A. Zheltov, A.A. Korolev, A.A. Kazakov, A.A. Leonov, J. Crystal Growth **285**, 215–227 (2005)
903. T.C. Shih, H.S. Kou, W.L. Lin, Int. Comm. Heat Mass Transfer **29**, 115–126 (2002)
904. T.C. Shih, H.S. Kou, W.L. Lin, Int. Comm. Heat Mass Transfer **30**, 975–985 (2003)
905. T.C. Shih, P. Yuan, W.L. Lin, H.S. Kou, Med. Eng. Phys. **29**, 946–953 (2007)

906. K. Shimada, E. Asahina, Cryobiology **12**, 209–218 (1975)
907. K. Shinozaki, K. Yamaguchi-Shinozaki, Curr. Opin. Plant Biol. **3**, 217–233 (2000)
908. E.E. Shnoll, A.G. Grivtsov, *Molecular Dynamics Method in Physical Chemistry* (in Russian) (Nauka, Moscow, 1996)
909. D. Shrivastava, R. Roemer, Int. J. Heat Mass Transfer **48**, 4090–4102 (2005)
910. D. Shrivastava, R. Roemer, Int. J. Heat Mass Transfer **47**, 4293–4300 (2005)
911. D. Shrivastava, R.B. Roemer, Phys. Med. Biol. **50**, 3627–3641 (2005)
912. W. Shyy, Int. J. Heat Mass Transfer **23**, 278–287 (2002)
913. W. Shyy, H.S. Udaykumar, in *Computational Analysis of Convective Heat Transfer*, ed. by B. Sunden, G. Comini (WIT Press, Southhampton, UK, 2000), pp. 141–198
914. S. Sidebottom, S. Buckley, P. Pudney, S. Twigg, C. Jarman, C. Holt, J. Telford, A. McArthur, D. Worall, R. Hubbard, P. Lillford, Nature **406**, 256 (2000)
915. E.N. Simonov, *X-ray computer tomography (in Russian)* (Russian Federal Nuclear Center, Snezhinsk, 2003)
916. S.J. Singer, G.L. Nicolson, Science **175**, 720–731 (1972)
917. J.D. Sipe, Ann. N.Y. Acad. Sci **961**, 1–9 (2002)
918. M. Smallwood, D.J. Bowles, Phil. Trans. R. Soc. Lond. B **357**, 831–847 (2002)
919. M. Smallwood, D. Worall, L. Byass, L. Elias, D. Ashford, C.J. Doucet, C. Holt, J. Telford, P. Lillford, D.J. Bowles, Biochem. J. **340**, 385–391 (1999)
920. K.C. Smith, J.C. Neu, W. Krassowska, Biophys. J. **86**, 2813– (2004)
921. N. Smolin, Dr. Rer. Nat. Thesis, Universität Dortmund, 2006
922. W.A. Snedden, H. Fromm, New Phytol. **151**, 35–66 (2001)
923. L.D. Son, Dr. Sci. Thesis, Ekaterinburg, Ural State Polytechnique University, 2007
924. L.D. Son, R.E. Ryltsev, Physica A **368**, 101–110 (2006)
925. Y.C. Song, B.S. Khirabadi, F. Lightfoot, K.G.M. Brockbank, M.J. Taylor, Nat. Biotechnol. **32**, 3–4 (2000)
926. A.S. Sonin, Sov. Phys. Usp. **30**, 875–896 (1987)
927. F.D. Sonnichsen, I.C. DeLuca, P.L. Davies, B.D. Sykes, Structure **4**, 1325–1327 (1996)
928. M.T. Sonoda, N.H. Moreira, L. Martínez, F.W. Favero, S.M. Vechi, L.R. Martins, M.S. Skaf, Brazil. J. Phys. **34**, 3–16 (2004)
929. H. Souzu, P. Mazur, Biophys. J. **23**, 89–100 (1978)
930. J.P. Sparks, G.S. Campbell, R.A. Black, Can. J. For. Res. **30**, 624–630 (2000)
931. J. Stachecki, Reprod. Biomed. Online **9**, 152–163 (2004)
932. R. Stacy, A. Eroglu, A. Fowler, J. Biggers, M. Toner, Cryobiology **52**, 99–117 (2006)
933. M. Stańczyk, J.J. Telega, Acta Bioengng. Biomech. **4**, 31–61 (2002)
934. M. Stańczyk, J.J. Telega, Acta Bioengng. Biomech. **5**, 3–22 (2003)
935. A. Stangeland, A. Mo, M. M'Hamdi, D. Viano, C. Davidson, Metall. Mater. Trans. A **37**, 705–714 (2006)
936. H.E. Stanley, Pramana **53**, 53–83 (1999)
937. H.E. Stanley, S.V. Buldryev, G. Franzese, N. Giovambattista, F. Starr, Phil. Trans. R. Soc. A **363**, 509–523 (2005)
938. H.E. Stanley, S.V. Buldyrev, N. Giovambattista, E.L. Nave, S. Mossa, A. Scala, F. Sciortino, F.W. Starr, M. Yamada, J. Stat. Phys. **110**, 1039–1053 (2003)

939. H.E. Stanley, S.V. Buldyrev, N. Giovambattista, E.L. Nave, A. Scala, F. Sciortino, F.W. Starr, Physica A **306**, 230–242 (2002)
940. H.E. Stanley, S.V. Buldyrev, A.L. Goldberger, Z.D. Goldberger, S. Havlin, R.N. Mantegna, S.M. Ossadnik, C.K. Peng, M. Simons, Physica A **205**, 214–253 (1994)
941. H.E. Stanley, S.V. Buldyrev, O. Mishima, M.R. Sadr-Lahijany, A. Scala, F.W. Starr, J. Phys. Condens. Matter **12**, A403–A412 (2000)
942. F.W. Starr, C.A. Angell, H.E. Stanley, Physica A **323**, 51–66 (2003)
943. F.W. Starr, J.K. Nielsen, H.E. Stanley, Phys. Rev. E **62**, 579–587 (2000)
944. P.S. Steif, M.C. Palastro, Y. Rabin, Med. Eng. Phys. **29**, 661–670 (2007)
945. P.S. Steif, M.C. Palastro, Y. Rabin, Cell Preserv. Technol. **5**, 104–115 (2007)
946. P.S. Steif, M.C. Palastro, C.R. Wan, S. Baicu, M.J. Taylor, Y. Rabin, Cell Preserv. Technol. **3**, 184–200 (2005)
947. A.A. Steiner, L.G.S. Branco, Ann. Rev. Physiol. **64**, 263–288 (2002)
948. P.L. Steponkus, Effects of freezing and cold acclimation on the plasma membrane of isolated protoplasts. US Dept. Energy. Progress Rep. DE-FG02-84ER13214, 1993, 7 pp.
949. P.L. Steponkus, D.G. Stout, J. Wolfe, R.E. Lovelace, J. Membr. Biol. **85**, 191–198 (1985)
950. J.S. Stier, D.L. Filiault, M. Wisniewski, J.P. Palta, Crop. Sci. **43**, 415–420 (2003)
951. F.H. Stillinger, T. Head-Gordon, Phys. Rev. E **52**, 2872–2877 (1995)
952. K.B. Storey, Cryobiology **52**, 1–16 (2006)
953. K.B. Storey, J. Bischof, B. Rubinsky, A. J. Physiol. Regul. Integr. Comp. Physiol. **263**, R185–R194 (1992)
954. K.B. Storey, J.M. Storey, Can. J. Zool. **64**, 49–56 (1986)
955. K.B. Storey, J.M. Storey, Ann. Rev. Ecol. Syst. **27**, 365–386 (1996)
956. K.B. Storey, J.M. Storey, in *Life in the Frozen State*, ed. by E. Benson, B. Fuller, N. Lane (CRC Press, Boca Raton, 2004), pp. 243–274
957. S.L. Stott, D. Irimia, J.O.M. Karlsson, Technol. Cancer Res. Treat. **3**, 113–123 (2004)
958. S.L. Stott, J.O.M. Karlsson, in *Summer BioEng. Conf.*, Sonesta Beach Resort, FL (2003)
959. G.B. Strambini, E. Gabellini, Biophys. J. **70**, 971–976 (1996)
960. C.S. Strom, X.Y. Liu, Z. Jia, J. Biol. Chem. **279**, 32407–32417 (2004)
961. C.V. Studholme, M.S. Thesis, University of Alberta, 1997
962. C. Sturesson, Medical laser-induced thermotherapy. Models and applications. Lund Report on Atomic Physics LRAP-235 (1998)
963. S. Sumida, *Cryo 2006*, Abstract Book (Hamburg, 2006) p. 134
964. S. Sumida, Cell Tissue Banking **7**, 265–365 (2006)
965. R. Sumimoto, N. Kamada, N.V. Jameson, Y. Fukuda, K. Dohi, Transplantation **51**, 589–593 (1991)
966. M.L. Sumpter, M.S. Thesis, Georgia Institute of Technology, 2004
967. F. Sun, G.X. Wang, K.M. Kelly, G. Aguitar, in *Proc. Int. Mech. Eng. Congr. Expos. IMECE 2005*, Orlando, Florida, USA, 2005, pp. 1–8
968. Q. Sun, H.F. Zheng, Chin. Phys. Lett. **23**, 3022–3024 (2006)
969. I.M. Swishchev, P.G. Kusalik, Phys. Rev. Lett. **73**, 975–978 (1994)
970. M.C.R. Symons, Phil. Trans. R. Soc. Lond. A **359**, 1631–1646 (2001)

971. J. Tacke, G. Adam, B. Sellhaus, A. Glowinski, I. Heschel, T. Schäffter, R. Schorn, S. Grosskortenhaus, G. Rau, R.W. Günter, Am. J. Neuroradiol. **22**, 431–440 (2001)
972. Y. Tada, A. Takimoto, H. Onishi, A. Oomori, *Cryo 2006*, Abstract Book (Hamburg, 2006), p. 165
973. M. Tadi, Inverse Problems **13**, 1585–1605 (1997)
974. E. Tajkhorshid, J. Cohen, A. Aksimentiev, M. Sotomayor, K. Schulten, in *Bacterial Ion Channels and their Eukaryotic Homologues*, ed. by B. Martinac and A. Kubalski, (ASM Press, Washington, DC, 2005), pp. 153–190
975. E. Tajkhorshid, F. Zhu, K. Schulten, in *Handbook of Materials Modeling, Vol. I: Methods and Models*, ed. by S. Yip (Springer, Netherlands, 2005), pp. 1797–1822
976. H. Takamatsu, Rep. Inst. Adv. Mat. Study, Kyushu Univ. **13**, 21–24 (1999)
977. M. Tanemura, T. Ogawa, N. Ogita, J. Comput.Phys. **51**, 191–207 (1983)
978. X. Tang, M.J. Pikal, Pharm. Res. **22**, 1167–1175 (2005)
979. A. Tanghe, P.V. Dijck, D. Colavizza, J.M. Thevelin, Appl. Environ. Microbiol. **70**, 3377–3382 (2004)
980. A.L. Tappel, in *Cryobiology*, ed. by H.T. Meryman (Academic Press, London, 1966), pp. 163–177
981. M. Tarek, Biophys. J. **88**, 4045–4053 (2005)
982. M.J. Taylor, R.N. Campbell, R.N. Rutledge, K.G.M. Brockbank, Transpl. Proc. **33**, 667–679 (2001)
983. S. Telenkov, J. Youn, A. Welch, T. Milner, Phys. Med. Biol. **46**, 551–558 (2001)
984. I.M. Ternov, Phys. Usp. **38**, 409–434 (1995)
985. J. Texter, M. Tirrell, AIChE J. **47**, 1706–1710 (2001)
986. R.R. Thakrar, V.P. Patel, G. Hamilton, B.J. Fuller, A.M. Seifalian, FASEB J. **20**, 874–881 (2006)
987. T. Tharasanit, B. Colenbrander, T.A.E. Stout, Reproduction **129**, 789–798 (2005)
988. D. Theodorescu, Rev. Urol. **6**(Suppl.4), S9–S19 (2004)
989. C. Thiebaut, D. Lemonnier, Int. J. Thermal Sci. **41**, 500–508 (2002)
990. S. Thirumala, J.M. Forman, W.T. Monroe, R.V. Devireddy, Nanotechnology **18**, 195104 (2007)
991. K.A. Thompson, J. Richa, S.A. Liebhaber, B.T. Storey, J. Androl. **22**, 339–344 (2001)
992. A.N. Tihonov, V.A. Arsenin, *Solution of Ill-Posed Problems* (Wiley, New York, 1977)
993. T. Todorova, A.P. Seitsonen, J. Hutter, UCRL-JRNL-215365, 2005
994. Y. Tokunaga, W.N. Wicomb, W. Concepcion, P. Nakazato, G.M. Collins, C.O. Esquivel, Surgery **110**, 80–86 (1991)
995. M.F. Tomashow, Rev. Plant Physiol. Plant Mol. Biol. **50**, 571–599 (1999)
996. M. Toner, E.G. Cravalho, D.R. Armant, J. Membr. Biol. **115**, 261–272 (1990)
997. M. Toner, E.G. Cravalho, M. Karel, J. Appl. Phys. **67**, 1582–1593; Erratum: 70, 4653, 1991 (1990)
998. M. Toner, E.G. Cravalho, J. Stachechki, T. Fitzgerald, R.G. Tompkins, M.L. Yamush, D.R. Armant, Biophys. J. **64**, 1906–1921 (1993)
999. M. Toner, E.G. Cravalho, J. Stachecki, T.F. Fitzgerald, R.G. Tomkins, M.L. Yarmush, D.R. Armant, Biophys. J. **64**, 1908–1921 (1993)

1000. J.D. Torres, P. Talens, I. Escriche, A. Chiralt, J. Food Eng. **74**, 240–246 (2006)
1001. F.S. Trad, M. Toner, J.D. Biggers, Human Reprod. **14**, 1569–1577 (1998)
1002. A.O. Trounson, Br. Med. Bull. **46**, 695–708 (1990)
1003. A.O. Trounson, L. Mohr, Nature **305**, 707–709 (1983)
1004. K. Tselunin, F. Seigneurin, E. Blesbois, Poultry Sci. **78**, 586–590 (1999)
1005. V.V. Tuchin, Phys. Usp. **40**, 495–515 (1997)
1006. S. Tungjikusolmun, S.T. Tyler, D. Haemmerich, J.Z. Tsai, H. Cao, J.G. Webster, F.T. Lee, D.M. Mahvi, V.R. Vorperian, IEEE Trans. Med. Eng. **49**, 3–8 (2002)
1007. J.R. Turk, M.H. Laughin, Can. J. Appl. Physiol. **29**, 657–683 (2004)
1008. M.G. Tyshenko, D. Doucet, P.L. Davies, V.K. Walker, Nat. Biotechnol. **15**, 887–890 (1997)
1009. H.S. Udaykumar, L. Mao, Int. J. Heat Mass. Transfer **45**, 4793–4808 (2002)
1010. H.S. Udaykumar, R. Mittal, W. Shyy, J. Comput. Phys. **153**, 535–574 (1999)
1011. D. Uhl, E. Hinsch, Reprod. Dom. Anim. **41**, 37–38 (2006)
1012. D.R. Uhlmann, B. Chalmers, K.A. Jackson, J. Appl. Phys. **35**, 2986–2992 (1964)
1013. US Department of Energy, Office of Science, A Science-Based Case for Large-Scale Simulation. v. 2 Washington, D.C. (2004)
1014. F.A. Väinölä, Ph.D. Thesis, University of Helsinki, Helsinki, 2000
1015. B.K. Vainstein, Sov. Phys. Usp. **9**, 251–275 (1966)
1016. T. Vajda, Cell. Mol. Life Sci. **56**, 398–414 (1999)
1017. G. Vali, in *Nucleation and Atmospheric Aerosols* ed. by M. Kulmula, P. Wagner (Pergamon Press, New York, 1996) pp. 271–279
1018. J.W. Valvano, Thermal properties. http: users.ece.utexas.edu/valvano/research/Thermal.pdf 1
1019. E. VanBavel, Prog. Biophys. Mol. Biol. **93**, 374–383 (2007)
1020. P. Vanderzwalmen, G. Bertin, C. Debauche, V. Standaert, E. van Rosendaal, M. Vandervorst, N. Bollen, H. Zech, T. Mukaida, K. Takahashi, R. Schoysman, Human Reprod. **17**, 744–751 (2002)
1021. A. Vanne, K. Hynynen, Phys. Med. Biol. **48**, 31–43 (2003)
1022. J. Vatamanu, P.G. Kusalik, J. Chem. Phys. **126**, 124703 (2007)
1023. A.A. Vedenov, E.B. Levchenko, Sov. Phys. Usp. **9**, 747–774 (1983)
1024. C. Vega, J.L.F. Abascal, J. Chem. Phys. **123**, 144,504 (2005)
1025. C. Vega, J.L.F. Abascal, E. Sanz, L.G. MacDowell, C. McBride, J. Phys. Condens. Matter **17**, S3283–S3288 (2005)
1026. R.I. Venkatasubramanian, E.D. Grassl, V.H. Barocas, D. Lafontaine, J.C. Bischof, Annals Biomed. Eng. **34**, 823–832 (2006)
1027. J.F. Verhey, Y. Mohammed, A. Ludwig, K. Giese, Phys. Med. Biol. **48**, 3595–3610 (2003)
1028. L. Vigh, P. Escribá, A. Sonnleitner, M. Sonnleitner, S. Piotto, B. Maresca, I. Horväth, J.L. Harwood, Prog. Lipid Res. **44**, 303–344 (2005)
1029. L. Vigh, D.A. Los, I. Horwath, N. Murata, Proc. Natl. Acad. Sci. USA **90**, 9090–9094 (1993)
1030. L. Vigh, B. Mareska, J.L. Hartwood, Trends. Biochem. Sci. **23**, 369–374 (1998)
1031. G. Vigier, G. Thollet, R. Vassoille, J. Cryst. Growth **84**, 309–315 (1987)
1032. C. Viswanathan, J. Zhu, J.K. Zhu, Physiol. Plant **126**, 52–61 (2006)
1033. C. Viswanathan, J.K. Zhu, Phil. Trans. R. Soc. Lond. B **357**, 877–886 (2002)
1034. S. Vogel, J. Biosci. **31**, 525–536 (2006)

1035. Y. Voituron, The Am. Naturalist **160**, 255–270 (2002)
1036. V.P. Voloshin, N.N. Medvedev, Y.I. Naberukhin, A. Gaiger, M. Klene, J. Struct. Chem. (in Russian) **46**, 451–458 (2005)
1037. B. Vonnegut, J. Appl. Phys. **18**, 593–595 (1947)
1038. A.V. der Vorst, Mikrotalasna Revija (Nov), 2–12 (2005)
1039. L. Vrbka, P. Jungwirth, Phys. Rev. Lett. **95**, 148501 (2005)
1040. L. Vrbka, P. Jungwirth, J. Mol. Liq. **134**, 54–70 (2007)
1041. H. Wada, J. Phys. Soc. Jpn. **72**, 3142–3150 (2003)
1042. J. Wahlberg, J.H. Southhard, F.O. Belzer, Cryobiology **23**, 477–482 (1986)
1043. P. Wainwright, Phys. Med. Biol. **45**, 2363–2372 (2000)
1044. H.A. Waldron, Phys. Med. Biol. **25**, 323–331 (1980)
1045. R. Wan, Z. Liu, K. Muldrew, in *Proc. 6th Int. Symp. Computer Methods in Biomech. Biomed. Eng.*, ed. by J. Middleton, N. Shrive, Madrid, 2004, pp. 1–8
1046. R. Wan, Z. Liu, K. Muldrew, J. Rewcastle, Comp. Meth. Biomech. Biomed. Eng. **6**, 197–208 (2003)
1047. J. Wang, A.G. Kalinichev, R.J. Kirkpatrick, Geochimica et Cosmochimica Acta **68**, 3351–3365 (2004)
1048. L. Wang, Ph.D. Thesis, University of Notre Dame (2005)
1049. S.Q. Wang, Z.Q. Zhou, Life Sci. **65**, 871–877 (1999)
1050. K. Watanabe, M. Oguni, M. Tadokoro, R. Nakamura, J. Phys. Condens. Matter **18**, 9375–9384 (2006)
1051. M. Watanabe, S. Arai, Agric. Biol. Chem. **51**, 557–563 (1987)
1052. J.C. Weaver, IEEE Trans. Plasma Sci. **28**, 24–33 (2000)
1053. S. Wei, X. Xiaobin, Z. Hong, X. Chuanxiang, Cryobiology **56**, 93–99 (2008)
1054. S. Weinbaum, L. Jiji, D.E. Lemons, J. Biomech. Eng. **106**, 331–341 (1984)
1055. S. Weinbaum, L.M. Jiji, J. Biomech. Eng. **107**, 131–139 (1985)
1056. M. Weinberg, R. Kapral, J. Chem. Phys. **91**, 7146–7152 (1989)
1057. S.J. Weiner, P.A. Kollman, D.A. Case, U.C. Singh, C. Ghio, G. Alagona, J.S. Profeta, P. Weiner, J. Am. Chem. Soc. **106**, 764–784 (1984)
1058. J.S. Wettlaufer, Phil. Trans. R. Soc. Lond A **357**, 3403–3425 (1999)
1059. J.S. Wettlaufer, M.G. Worster, Annu. Rev. Fluid Mech. **38**, 427–452 (2006)
1060. D.A. Wharton, D.J. Ferns, J. Exper. Biol. **198**, 1381–1387 (1995)
1061. D. Whittaker, Br. Dent. J. **139**, 459–465 (1975)
1062. D.G. Whittingham, M.F. Lyon, P.H. Gleniser, Genet. Res. **29**, 177–181 (1977)
1063. T.A. Whittingham, Progr. Biophys. Mol. Biol. **93**, 84–110 (2007)
1064. P. Widehem, N. Cochet, Process Biochem. **39**, 405–410 (2003)
1065. R.J. Williams, Cryobiology **26**, 568 (1989)
1066. S.B. Wilson, V.A. Spence, Phys. Med. Biol. **33**, 895–912 (1988)
1067. M. Wisniewski, M. Fuller, D.M. Glenn, J. Palta, J. Carter, L. Gusta, M. Griffith, J. Duman, Búïsindi. Icel. Agr. Sci. **14**, 41–47 (2001)
1068. E.H. Wissler, J. Appl. Physiol. **85**, 35–41 (1998)
1069. L.A. Withers, M.R. Davey, Protoplasma **94**, 207–219 (1978)
1070. A. Woitowicz, S. Stelmann, J. Jankun, Comput. Aided Surg. **8**, 91–98 (2003)
1071. J. Wolfe, *Encyclopedia of Life Sciences* (Macmilllan, New York, 2002) pp. 1–17
1072. J. Wolfe, G. Bryant, Cryobiology **39**, 103–129 (1999)
1073. J. Wolfe, G. Bryant, K.L. Koster, Cryo Letters **23**, 157–166 (2002)
1074. J. Wolfe, M.F. Dowgert, P.L. Steponkus, J. Membr. Biol. **86**, 127–138 (1985)
1075. J. Wolfe, P.L. Steponkus, Plant Physiol. **71**, 276–285 (1983)

1076. W.F. Wolkers, S.K. Balasubramanian, E.L. Ongstad, H.C. Zec, J.C. Bischof, Biochim. Biophys. Acta **1768**, 728–736 (2007)
1077. D. Worall, L. Elias, D. Ashford, M. Smallwood, C. Sidebottom, P. Lillford, J. Tellford, C. Holt, D. Bowles, Science **282**, 115–117 (1998)
1078. E.J. Workman, S.E. Reynolds, Phys. Rev. **78**, 254–259 (1950)
1079. B.A. Workmaster, J. Palta, M. Wisniewski, J. Am. Soc. Horticult. Sci. **124**, 619–625 (1999)
1080. B. Wowk, E. Leitl, C.M. Rasch, N. Mesbah-Karimi, S.B. Harris, G.M. Fahy, Cryobiology **40**, 228–236 (2000)
1081. H.L. Wu, Y. Ma, X.F. Peng, Chin. Phys. Lett. **21**, 345–347 (2004)
1082. J. Wu, Prog. Biophys. Mol. Biol. **93**, 363–373 (2007)
1083. Y.L. Wu, S. Weinbaum, L. Jiji, Int. J. Heat Mass Transfer **36**, 1073–1083 (1993)
1084. M.C. Wusterman, U. Rauen, J. Simmonds, N. Hunds, D.E. Pegg, Cryobiology **56**, 72–79 (2008)
1085. M.C. Wusterman, J. Simmonds, D. Vaughan, D.E. Pegg, Cryobiology **56**, 62–71 (2008)
1086. S.S. Xantheas, T.H.J. Dunning, J. Chem. Phys. **99**, 8774–8792 (1993)
1087. X. Xe, J. Bischof, ASME J. Biomech. Eng. **127**, 656–661 (2005)
1088. J. Xu, B.M. Zou, P. Xu, J. Phys. D Appl. Phys. **39**, 4486–4490 (2006)
1089. K.C. Xu, L.Z. Niu, W.B. He, Y.S. He, Y.F. Li, J.S. Zuo, World J. Gastroenterol. **14**, 1603–1611 (2008)
1090. Y. Xu, T.C. Hua, D.W. Sun, G.Y. Zhou, F. Xu, J. Biomech. **40**, 3201–3206 (2007)
1091. M. Yamada, S. Mossa, H.E. Stanley, F. Sciortino, Phys. Rev. Lett. **88**, 195701 (2002)
1092. J.F. Yan, J. Liu, Nanomed. Nanotechnol. Biol. Med. **4**, 79–87 (2008)
1093. Z. Yan, S.V. Buldyrev, N. Giovambattista, H.E. Stanley, Phys. Rev. Lett. **95**, 130604 (2005)
1094. Z. Yan, S.V. Buldyrev, P. Kumar, N. Giovambattista, P.G. Debenetti, H.E. Stanley, Phys. Rev. E **76**, 051201 (2007)
1095. K.T. Yang, S.F. Pan, C.I. Chen, S.M. Hsu, Y.Z. Tseng, S.M. Yang, M.L. Wu, FASEB J. **18**, 1442–1444 (2004)
1096. W.I. Yang, T. Addona, D.G. Nair, L. Qi, T.S. Ravikumar, Int. J. Cancer **103**, 360–369 (2003)
1097. W.L. Yang, T. Addona, D.G. Nair, L. Qi, T.S. Ravikumar, Int. J. Cancer **103**, 360–369 (2003)
1098. Y.H. Yong, J.M. Pope, J. Wolfe, Biophys. J. **74**, 1949–1965 (1998)
1099. Y.H. Yoon, J. Pope, J. Wolfe, Cryobiology **46**, 271–276 (2003)
1100. H. Yu, W.F. van Gunsteren, J. Chem. Phys. **121**, 9549–9564 (2004)
1101. L. Yu, J. Liu, Forsch. Ingenieurwes. **71**, 125–134 (2007)
1102. T.H. Yu, J. Ling, Y.X. Zhou, Cryobiology **50**, 174–182 (2005)
1103. T.H. Yu, J. Liu, Y.X. Zhou, Anal. Bioanal. Chem. **378**, 1793–1800 (2004)
1104. T.H. Yu, Y.X. Zhou, J. Liu, Int. J. Thermophys. **24**, 513–531 (2003)
1105. Z.W. Yu, P.J. Quinn, Biochim. Biophys. Acta **1509**, 440–450 (2000)
1106. K. Yue, X. Zhang, F. Yu, J. Thermal Sci. **13**, 255–258 (2004)
1107. K. Yue, X. Zhang, F. Yu, Int. J. Thermophys. **28**, 1470–1489 (2007)
1108. K.E. Zacharianssen, H.T. Hammel, Nature **262**, 285–287 (1976)
1109. K.E. Zacharianssen, J.A. Husly, Nature **298**, 865–867 (1982)

1110. K.E. Zacharianssen, E. Kristiansen, Cryobiology **41**, 257–279 (2000)
1111. R. Zangi, J. Phys.: Condens. Matter **16**, S5371–S5388 (2004)
1112. J.M. Zanotti, M. Bellissent-Funel, S. Chen, Europhys. Lett. **71**, 91–97 (2005)
1113. N.E. Zaritsky, in *Managing Frozen Foods*, ed. by C. Kennedy (Woodhead, Cambridge, 2000) pp. 111–134
1114. P.M. Zavos, E.F. Graham, Cryobiology **20**, 553–559 (1983)
1115. A. Zewall, Phil. Trans. R. Soc. **364**, 315–329 (2005)
1116. A. Zhang, L.X. Xu, G.A. Sandison, S. Cheng, Phys. Med. Biol. **51**, 6047–6060 (2006)
1117. A. Zhang, L.X. Xu, G.A. Sandison, J. Zhang, Cryobiology **47**, 143–154 (2003)
1118. H. Zhang, Phys. Med. Biol. **53**, N15–N23 (2008)
1119. Q. Zhang, Y. Cong, S. Qu, S. Luo, G. Yang, J. Ocean Univ. Chin. **7**, 65–71 (2008)
1120. Q. Zhang, T.H. Jackson, A. Ungan, D. Gao, Int. J. Heat Mass Transfer **42**, 395–403 (1999)
1121. X. Zhang, H. Gu, M. Fujii, Int. J. Thermophys. **27**, 569–580 (2006)
1122. Y.T. Zhang, J. Liu, Y.X. Zhou, Forsch. im Ingenier. **67**, 188–197 (2002)
1123. G. Zhao, X. Bai, D. Luo, D. Gao, Cryo Letters **27**(2), 115–126 (2006)
1124. G. Zhao, D.W. Luo, Z.F. Liu, D.Y. Gao, Latin Am. Appl. Res. **37**, 215–222 (2007)
1125. G. Zhao, H. Zhang, X.J. Guo, D. Luo, D.Y. Gao, Med. Eng. & Phys. **29**, 205 (2007)
1126. H.K. Zhao, T. Chan, B. Merrimam, S. Osher, J. Comput. Phys. **127**, 179–195 (1996)
1127. A.I. Zhmakin, in *Keynote lecture. ICHMT Int. Symp. on Advances in Computational Heat Transfer*, 2004, Norway. CD-ROM Proc., Begell House Inc. 24 pp.
1128. A.I. Zhmakin, Phys. -Usp. **51**, 231–252 (2008)
1129. A.I. Zhmakin, D.K. Ofengeim, Tech. Phys. Lett. **32**, 765–767 (2006)
1130. A.I. Zhmakin, D.K. Ofengeim, in *Problems of Mathematical Physics and Applied Mathematics*, ed. by E.A. Tropp, E.V. Galaktionov (Ioffe Physical Technical Institute, Saint Petersburg, 2007)
1131. F. Zhu, K. Schulten, Biophys. J. **85**, 236–244 (2003)
1132. F. Zhu, E. Tajkhorshid, K. Shulten, Biophys. J. **86**, 50–57 (2004)
1133. L. Zhu, S. Weinbaum, J. Biomech. Eng. **117**, 64–73 (1995)
1134. Y. Zhu, S. Granick, Phys. Rev. Lett. **87**, 096,104 (2001)
1135. Y. Zinchenko, E. Laureano, R. Coger, Cell Preserv. Techn. **2**, 276–289 (2004)
1136. S. Zlochiver, M.M. Radai, M. Rosenfeld, S. Abboud, Annals Biomed. Eng. **30**, 1172–1180 (2002)
1137. S. Zlochiver, M. Rosenfeld, S. Abboud, Annals Biomed. Eng. **33**, 616–625 (2005)

Index