JOURNAL OF MOLECULAR RECOGNITION
J. Mol. Recognit. 2005; **18**: 1–39
Published online 18 November 2004 in Wiley InterScience (www.interscience.wiley.com). DOI:10.1002/jmr.726

Review

Survey of the year 2003 commercial optical biosensor literature

Rebecca L. Rich and David G. Myszka*
Center for Biomolecular Interaction Analysis, University of Utah, Salt Lake City, Utah, USA

In the year 2003 there was a 17% increase in the number of publications citing work performed using optical biosensor technology compared with the previous year. We collated the 962 total papers for 2003, identified the geographical regions where the work was performed, highlighted the instrument types on which it was carried out, and segregated the papers by biological system. In this overview, we spotlight 13 papers that should be on everyone's 'must read' list for 2003 and provide examples of how to identify and interpret high-quality biosensor data. Although we still find that the literature is replete with poorly performed experiments, over-interpreted results and a general lack of understanding of data analysis, we are optimistic that these shortcomings will be addressed as biosensor technology continues to mature.

Keywords: **affinity; Biacore; biomolecular interaction analysis; evanescent wave; IAsys; kinetics; optical biosensor; resonant mirror; Spreeta; surface plasmon resonance**

Received 16 August 2004; accepted 27 August 2004

INTRODUCTION

It has been 13 years since the release of the first commercially available optical biosensor and by all accounts the technology has been a success. Biosensors have revolutionized the study of macromolecular interactions. Along the way, they have become the gold standard against which other interaction technologies are compared. Based on the publication record, we find the types of applications and the user base are continuing to expand at a healthy rate. However, while there is a small cadre of research groups who clearly understand how to apply the technology, the prevalence of ill-performed experiments or over-interpreted data in the literature is disappointing. In many ways, biosensor technology is going through its own adolescent growing pains. New users must experience first hand the challenges in setting up a biosensor experiment correctly and learn how to properly interpret data. New and old users alike must be cautious with the technology, remembering that, while the biosensor monitors biology at its most fundamental level, the data output reflects the quality of the reagents and operator attentiveness. So as both the technology and user base mature, we should all expect some challenges.

This year we highlight 13 papers that we recommend all biosensor users add to their reference library. These papers demonstrate the level of experimental error obtained from a variety of operators, as well as a range of biological systems, analysis types, instruments and assay designs. In an effort to educate users, we also present examples of good and bad sensor data so that users will know what to look for in their own work. And finally, we discuss how to visually interpret binding profiles using examples commonly found in the literature.

*Correspondence to: D. G. Myszka, Center for Biomolecular Interaction Analysis, University of Utah, Salt Lake City, UT 84132, USA.
E-mail: dmyszka@cores.utah.edu

Abbreviations used: CBP, chemokine binding protein; ITC, isothermal calorimetry; SAM, self-assembled monolayers.

LITERATURE OVERVIEW

In 2003, 962 papers that described work using commercially available optical biosensors were published in 273 different journals. This list represents a 17% increase in the number of articles compared with the year 2002, as well as an 8% increase in the number of journals publishing biosensor data. Although most studies were published in the *Journal of Biological Chemistry* (159 articles) *Biochemistry* (49), and the *Journal of Molecular Biology* (28), biosensor-based research was published in journals ranging from *Advanced Materials* and *Biometals* to *Arthritis and Rheumatism* and *Thorax* to *Food Control* and the *International Dairy Journal*. Together, these publications demonstrate the optical biosensor's expanding utility in traditional fields of life science research and drug discovery, as well as its emerging contribution in engineering disciplines, agriculture and bioproduction. Since biosensor data is now published in such a wide variety of journals, no single database is able to encompass this literature. Finding the articles for this year's review therefore required searching all of the major biological and physical sciences databases. In each search, we scanned the full text of articles for key words such as 'surface plasmon resonance' and 'optical biosensor', and commercial instrument names (i.e. Biacore, IAsys, Spreeta, etc.). We limited our search to articles published in English-language journals and omitted those that described work performed using non-commercial biosensors. While we have attempted to include every relevant article, it is possible we have missed a few. To ensure that your article

is included in any future survey, remember to include keywords that will aid the search engines.

The compiled list of articles at the end of this survey is divided into two major sections: articles that review the current state and future direction of optical biosensors or describe application-specific methods[1–67] and original research articles that use biosensors in a wide range of applications.[68–962]

REVIEWS AND METHODS

Reviews by Jain and Leonard *et al.* provide general introductions to optical biosensor technology[23,28] and others describe the fundamentals of surface plasmon resonance,[21,55] evanescent wave generation,[15,16,52] and mass transport.[50] Van Regenmortel also discussed critical issues in both the design and analysis of biosensor experiments[50] and, in our survey of the year 2002 literature, we highlighted examples of well-performed kinetic, equilibrium, competition, and active concentration analyses.[42] In addition, several reviews compare the advantages and disadvantages (including sample preparation requirements, sensor sensitivity, and the range of applications) for optical biosensors and other interaction technologies such as quartz crystal microbalance,[5,25,31,34,51] surface acoustic wave,[10,25] calorimetry,[10] and fluorescence spectroscopy.[12,48]

Optical biosensors' impact in specific areas of life science research, drug discovery and medical applications is demonstrated in several review articles. In particular, a number of reviews describe the technology's contribution in understanding membrane[1,35] and carbohydrate biology,[14,32] T cell antigen recognition,[13,49] HIV–host interactions,[43] protein isomerization[58] and assembly of multi-protein complexes.[53] References 4, 8, 11, 17, 30 and 36 illustrate how optical biosensors are used in each phase of drug discovery and development, from target identification/characterization/validation and ligand fishing/hit confirmation to compound screening/lead optimization, ADME and toxicity studies. Other reviews focused on the biosensor's increasing role in immunogenicity testing of therapeutic agents;[20,40,47,54] for example, Swanson emphasized how optical biosensors can be used to detect both high- and low-affinity antibodies produced against therapeutics.[47] Also, a number of reviewers recognized the need for higher-throughput optical biosensors in streamlined drug discovery: they described the biosensor's potential in an array format, as well as the accompanying development of protein chips.[9,10,19,22,24,26,29,39,41,56,57,59,60]

Several references provide step-by-step protocols for specific biosensor applications, including protein/carbohydrate interactions,[64,66] small molecules binding to RNA,[67] TCR/MHC class II interactions,[62] and ligands binding to receptors embedded in retroviral pseudotypes.[65] In addition, references 14 and 63 emphasized the care required to design and execute high-quality biosensor experiments, process and analyze primary data, and present informative figures. These authors also highlighted practical considerations, including selecting the application-appropriate chip and immobilization method, checking for self-consistency by comparing the interaction affinity obtained by equilibrium analysis and from the ratio of kinetic parameters, choosing appropriate regeneration conditions, using low surface densities and high flow rates, and dealing with potential pitfalls such as non-specific binding, steric hindrance, and sample degradation, avidity and/or aggregation.

STATISTICS OF ORIGINAL RESEARCH ARTICLES

There were 895 primary research articles published in 2003 that reported using commercial optical biosensors. Figure 1 illustrates that authors in 35 countries around the world published biosensor-based work. Most reports came from institutions in Europe (369, 41%), the USA (288, 32%) and Japan (123, 14%). In the USA, the most articles were produced by investigators from California (59), with significant contributions also from groups in Massachusetts (29), Maryland (25) and Pennsylvania (21) [Fig. 1(B)]. In Europe, the greatest number of articles was published by researchers in Germany (75), the UK (64) and France (64) [Fig. 1(C)].

Biosensor platforms

This year's published work was performed using instruments produced by 10 manufacturers (Table 1; at this time it appears that only biosensors from Biacore, Texas Instruments, Autolab, Optrel, Analytical μ-systems and Eco Chemie are available for purchase in the USA and other major markets). As reflected in Fig. 2(A), the vast majority of the literature described work performed using Biacore platforms (813, 91%). Because of the large number of users applying Biacore-based technology, we have focused the remainder of this survey on the experiments performed using these instruments, but many of the points we emphasize can be applied to all of the technologies.

Figure 2(B) shows that most Biacore users reported data collected from Biacore 2000 (269, 33%), 3000 (194, 24%), X (104, 13%) and 1000 (58, 7%) instruments. Some 170 articles (21%) described experiments that used Biacore instruments but did not state which platform was used (or these may have been done on the first version of the technology, which was simply referred to as Biacore). The automation, reliability and versatility of the Biacore 2000 and 3000 make these two platforms the workhorses of biosensor technology (as shown in references 324, 384, 662, and 788, each of which we discuss in detail later in this survey). Good-quality data, however, can also be obtained using the Biacore X[70,81,261,352] and 1000.[71,264,298,448] There were a number of papers illustrating work performed using the two most recently released platforms, Biacore Q (for food analysis)[841,844,845,847,852–855] and Biacore S51 (for rapid screening and ultra-high-resolution kinetic analyses of small molecules).[434,561,779,783] Six references describe data obtained from the J[144,183,547,823] and BIAlite platforms.[534,655]

Biological applications

Figure 2(C) shows the distribution of publications based on the types of biological systems that were studied. The

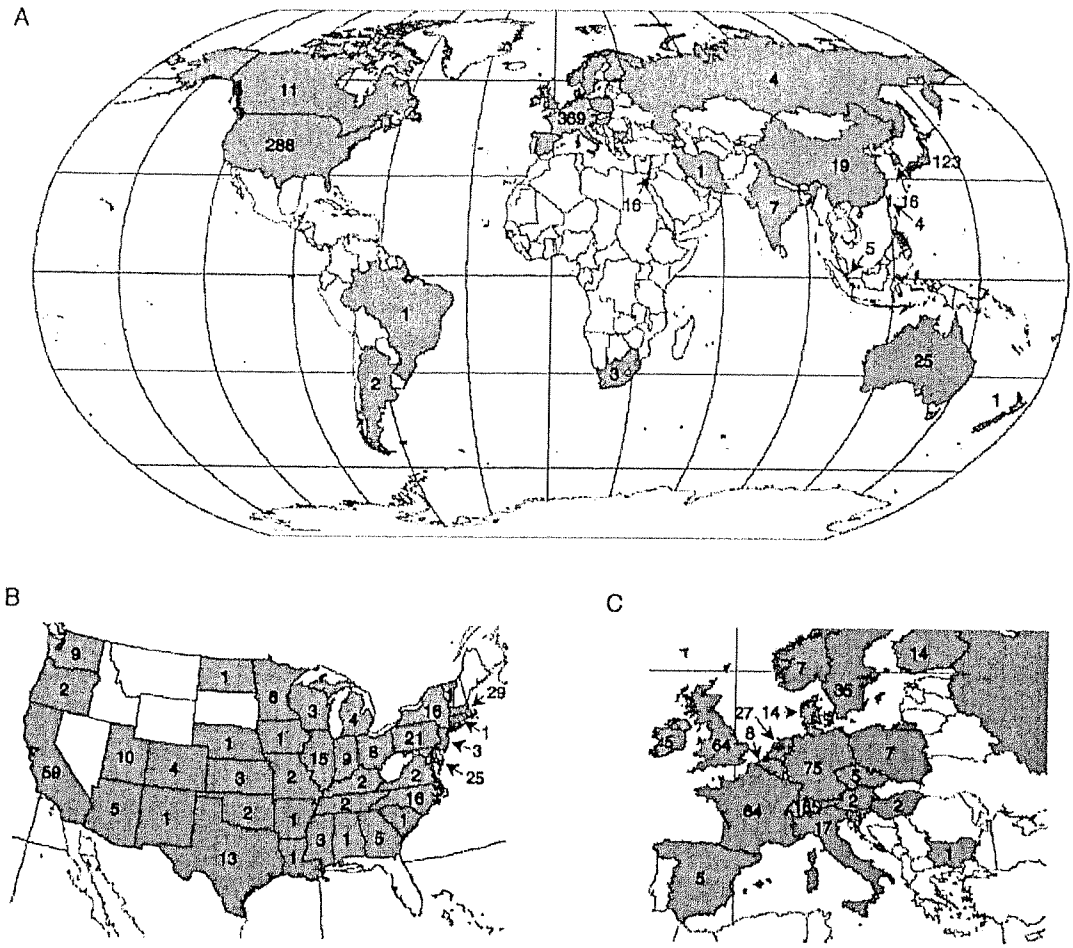

Figure 1. Distribution of biosensor articles published in the year 2003: worldwide (A) and within the USA (B) and Europe (C). Locations are based on the address of the first author.

Table 1. Commercial optical biosensors

Manufacturer	Instruments[a]	Website	References
Biacore AB	Biacore, Bialite, Q, J, X, 1000, 2000, 3000, S51	www.biacore.com	68–880
Affinity Sensors	IAsys, IAsys+, IAsys Auto	www.affinity-sensors.com	881–925
Texas Instruments	TISPR-1, Spreeta, Spreeta 2000	www.ti.com	926–937
DKK-TOA	SPR-20	www.dkktoa.net	938–943
Optrel GbR	Multiskop	www.optrel.de	944–947
Windsor Scientific Ltd	IBIS I, IBIS II	www.windsor-ltd.co.uk	948–951
Artificial Sensing Instruments	BIOS-1[b]	www.microvacuum.com	952–954
Eco Chemie BV	Autolab	www.ecochemie.nl	955–957
Nippon Laser & Electronics	SPR-670	www.nle-lab.co.jp	958–960
Analytical μ-systems	BIO-SUPLAR	www.micro-systems.de	961, 962

[a] Instruments used in 2003 publications, not necessarily all instruments produced by a manufacturer.
[b] Now called OWLS.

application of biosensors is fairly evenly divided between proteins,[68–235] antibodies,[236–358] receptors,[359–451] peptides,[452–545] and oligonucleotides,[546–645] while the technology's impact in lipid and self-assembled monolayer,[646–704] extracellular matrix,[705–749] carbohydrate,[750–771] and small molecule[772–817] studies has grown steadily over the past few years. Biosensors are also increasingly used in clinical applications (such as quantitating antibody titers in animal models and human participants in drug trials and diagnosing diseases in patients),[818–840] as well as in food, veterinary and environmental testing (for example, to track yield and monitor quality control of bioproducts, detect contaminants in food and environmental samples, and monitor the health of veterinary animals).[841–856] Also, improvements in mass

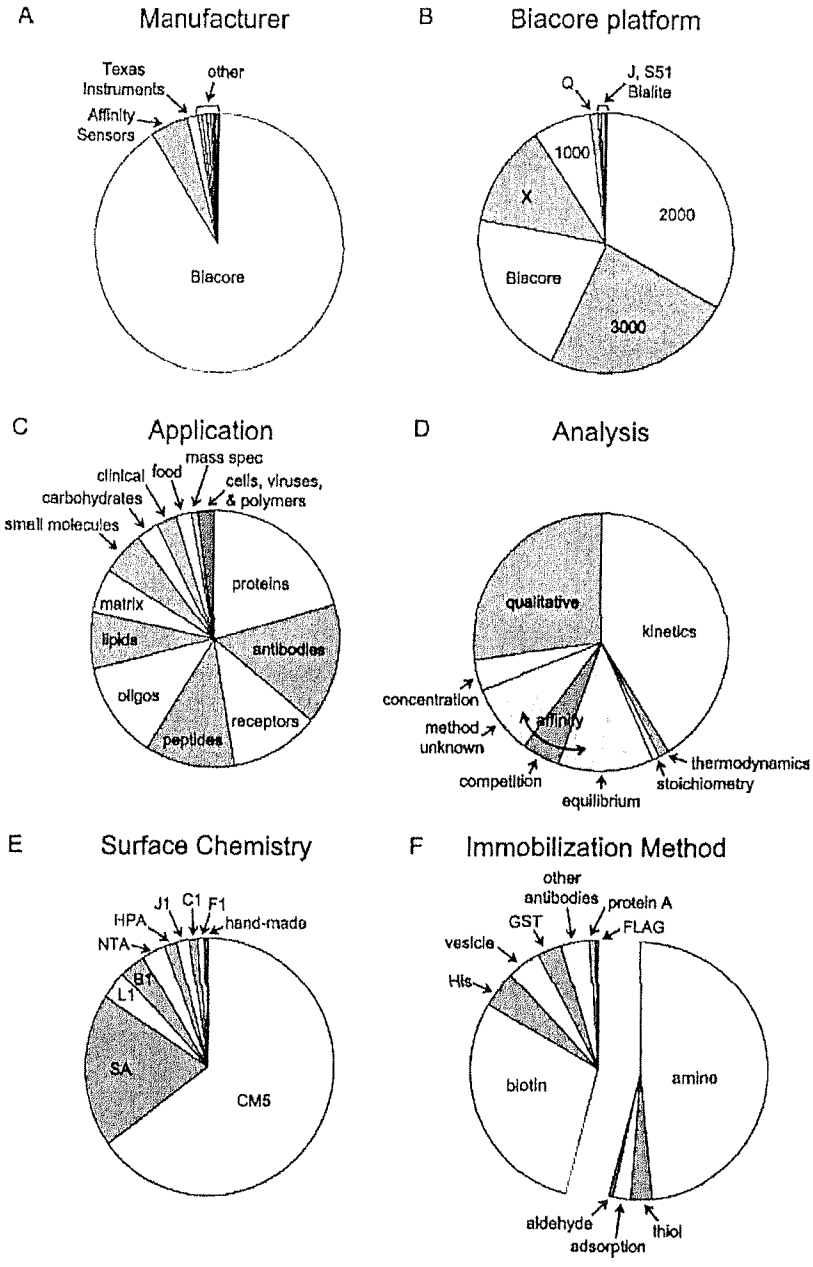

Figure 2. Pie charts showing the research articles categorized by various experimental parameters. (A) Manufacturer. The wedges grouped as 'other' include DKK-TOA, Optrel GbR, Windsor Scientific Ltd., Artificial Sensing Instruments, Eco Chemie BV, Nippon Laser and Electronics, and Analytical μ-systems. (B) Biacore platform. The wedge denoted 'Biacore' represents articles that either used the original Biacore instrument or did not state specifically which model was used. (C) Biological application. The articles in the reference list are grouped according to the classifications in this chart. (D) Analysis format. The wedge denoted 'method unknown' represents articles that reported K_Ds but did not state which format (kinetic, equilibrium, or competition analysis) was used. (E) Surface chemistry, using the names of the different Biacore sensor chips. (F) Immobilization method, with the pie chart split into two segments: capturing (left) and direct coupling (right). Except for (A), these pie charts reflect the statistical analysis of Biacore-based articles.

spectrometry-coupled biosensor technology continue,[857–863] as does the development of biosensor assays to characterize fibrils, synthetic polymers, viruses, whole cells and other complex systems.[864–880]

Analysis formats

Figure 2(D) shows the distribution of analysis formats. The biosensor was used most often to measure kinetic

rate constants (351, 43%) and interaction affinity (209, 26%; while 47% of affinities were determined using equilibrium analyses and 18% using competition analyses, 35% of the time the method used to obtain the K_D was not reported). Two-hundred and twenty-one articles (27%) describe qualitative analyses: identifying binding partners,[388,429,567] establishing specificity,[191,648,735,750,765] mapping epitopes[265,324,351] following molecular assembly,[438,522] or comparing binding mechanisms.[280,573,604] Thirty-two articles (4%) describe using the biosensor to determine analyte concentrations (either the total concentration of analytes such as drug residues, metabolites, and pesticides[826,850,852,854] or the active fraction of antibodies and other proteins[220,288,300]) and 19 (2%) used the biosensor to examine interaction thermodynamics[142,143,173,400,411,448,468,527,632,648,773,805] and stoichiometry.[130,211,257,389,716,770,817]

Surface chemistries

Of the 662 (74%) papers that reported what sensor surface chemistry was used in the analysis, 65% used the CM5 chip, which is coated with a layer of carboxymethyldextran [Fig. 2(E)]. The SA chip, a chip with streptavidin pre-immobilized and dedicated to capturing biotinylated ligands, was used 19% of the time. The remainder of experiments employed L1 (coated with alkane-modified dextran; 4%) and HPA (hydrophobic layer of alkanethiols, 3%) to prepare lipid surfaces,[430,662,704] B1 (the lower-charged version of the CM5 and now referred to as CM4; 3%) for minimizing non-specific binding and charge repulsion,[229,377,403] NTA (nickel-derivatized dextran; 2%) to capture His-tagged ligands,[850,870,875] J1 (plain gold surface, 1%) for simple protein adsorption,[678,835,874] the C1 (a carboxylated gold surface; 1%), and F1 (coated with short dextran layer; 1%) for high-molecular-mass analytes,[438,864,871] or user-defined chips (1%) intended for self-assembled monolayer surfaces.[667,675–677,679,680,703]

Immobilization methods

Of the 676 papers (76%) that described how ligand surfaces were prepared, 54% used direct immobilization and 46% used some capturing method [Fig. 2(F)]. Ligands were immobilized using amine- (90%), thiol- (5%),[143,169,377] or aldehyde-coupling (1%)[317,768,827] chemistries or simple adsorption or immersion (4%).[658,663,686] Ligands were most often captured using biotin (64%), anti-His mAbs (10%), anti-GST mAbs (7%), or anti-FLAG mAbs (1%).[371,540] Alternatively, 8% of ligands were captured by user-specific antibodies[362,366,376] and 2% by protein A,[93,749,750] while lipid surfaces were most often prepared by vesicle capture (used 8% of the time).

MUST-READ ARTICLES FROM 2003

Below we spotlight 13 articles that should be in every biosensor user's reference library. The work described in these articles helps further validate the biosensor technology (article 1), provide examples of well-performed experiments in various biological applications (articles 2–6) and analysis formats (articles 7–9), illustrate advances in ligand surface preparation (articles 10 and 11), and exemplify the importance of detailing the experimental design along with including informative figures of the data (articles 12 and 13).

1. Technology validation

The ABRF-MIRG'02 Study: assembly state, thermodynamic, and kinetic analysis of an enzyme/inhibitor interaction. Myszka DG *et al.* (2003) *J. Biomol. Tech.* **14**: 247–269.

A study coordinated by the Association of Biomolecular Resource Facilities' Molecular Interactions Research Group (ABRF-MIRG) established the experimental variability between biosensor users. ABRF-MIRG invited 30 participants using six different platforms to examine the same molecular interaction: a small-molecule inhibitor in solution binding to an immobilized enzyme. Figure 3(A) shows a sampling of 12 of the 60 returned data sets. The binding response profiles appear similar and could be described by a simple interaction model to yield kinetic rate constants of $k_a = (4.0 \pm 0.7) \times 10^4\ \mathrm{M}^{-1}\mathrm{s}^{-1}$ and $k_d = 0.036 \pm 0.007\ \mathrm{s}^{-1}$ for the entire participant panel. This study demonstrated that, when multiple users are provided with the same samples and apply similar protocols, the experimental error in the rate constants is about 20%. To compare the surface-based results with those obtained from solution-based methods, 14 participants measured the same interaction using isothermal calorimetry (ITC). Figure 3(B) illustrates that, within experimental error, ITC and biosensor users obtained the same affinity ($K_D^{SPR} = 0.90 \pm 0.22\ \mu\mathrm{M}$ and $K_D^{ITC} = 1.00 \pm 0.22\ \mu\mathrm{M}$) and the error ranges were similar. This study demonstrated that immobilizing the ligand on the sensor surface did not alter the interaction, which has been a common concern regarding the binding parameters reported from biosensor analyses. Together, the comparisons across the participant panel and between the interaction technologies validated the biosensor as a biophysical tool. This paper provides very detailed methods if you would like to repeat the analysis. In addition, the reagents, which are commercially available, and methods used in this study can serve as teaching tools for new users, as well as test systems for evaluating other biosensors or interaction technologies.

2. Protein interactions

Mechanism for multiple ligand recognition by the human transferrin receptor. Giannetti AM *et al.* (2003) *PLoS Biol.* **1**: 341–350.

Giannetti *et al.*'s analysis of soluble transferrin and its immobilized receptor is an excellent example of how biosensors can be used to characterize protein–protein interactions. They examined how the kinetics and affinity were affected when specific residues in the receptor were mutated, as well as differences in receptor recognition between apo- and holo-transferrin. Even from a simple inspection of the binding responses in Fig. 4, we can compare response levels and binding profiles to evaluate

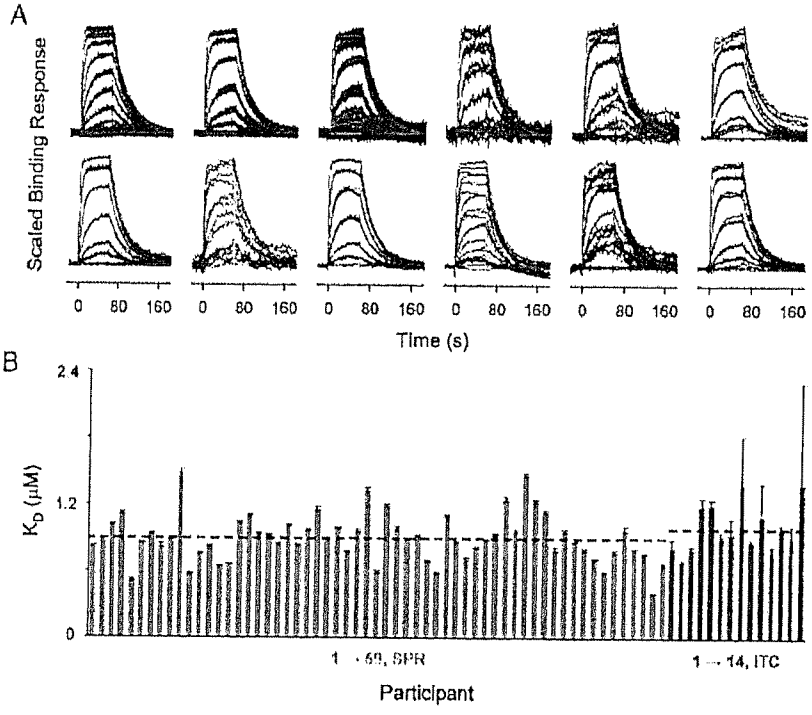

Figure 3. Reproducibility of biosensor experiments. (A) Subset of binding responses (black lines) and fits to a 1:1 interaction model (red lines) for a test system analyzed by study participants using six different biosensor platforms. (The entire 60-panel figure is shown in reference 805.) (B) Comparison of Biacore- (green) and ITC- (red) derived affinities for the enzyme–inhibitor interaction. The dashed lines and colored bands represent the averages and standard deviations obtained from the two types of analyses. Adapted from ref. 805 with permission from the Association of Biomolecular Resources Facilities © 2003.

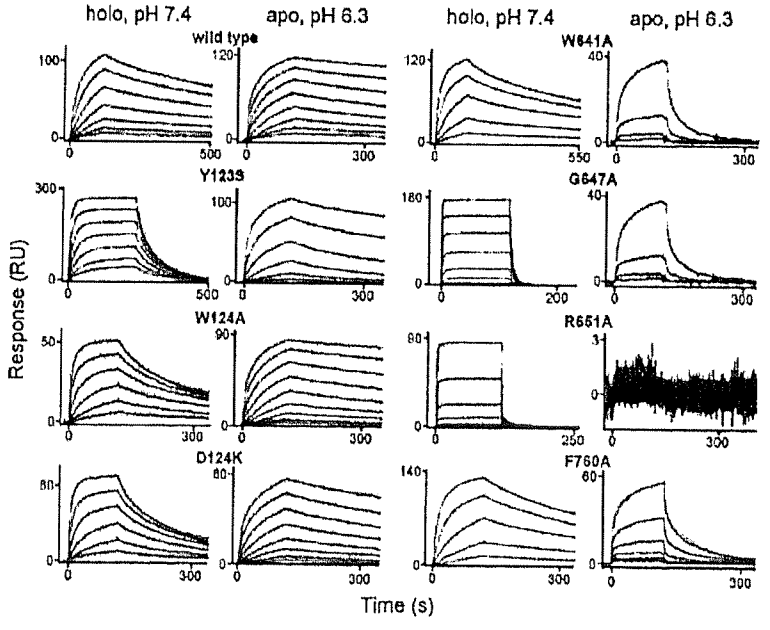

Figure 4. Kinetic analysis of apo- and holo-transferrin binding to immobilized wild type and mutant transferrin receptor. The binding responses (black lines) are superimposed with the fit of the chosen interaction model (red lines). Adapted from reference 384 with permission from PLoS Journals and Giannetti *et al.* © 2003.

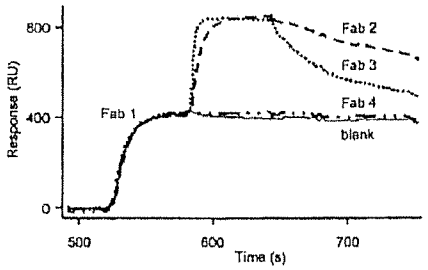

Figure 5. Epitope mapping of Fabs against fibroblast growth factor receptor 3. Adapted from reference 324 with permission from the American Society for Biochemistry and Molecular Biology © 2003.

which changes altered the association rate, dissociation rate or both. Using this kinetic information, these researchers mapped the binding interface and developed a model to describe how the receptor mediates transferrin activity. Other notable examples of well-performed protein–protein studies are described in references 82, 85, 201 and 223.

3. Competitive epitope mapping

Human combinatorial Fab library yielding specific and functional antibodies against the human fibroblast growth factor receptor 3. Rauchenberger R *et al.* (2003) *J. Biol. Chem.* **278**: 38194–38205.

Since they were first released, commercial optical biosensors have been used to characterize antibodies by identifying antigen binders, mapping binding epitopes, and yielding kinetic and affinity parameters. For example, Fig. 5 depicts Rauchenberger *et al.*'s epitope mapping of Fabs against fibroblast growth factor receptor 3. No increase in response is observed when Fab4 was injected over the Fab1/receptor complex ($t > 580$ s), indicating these two Fabs compete for receptor binding. In contrast, the binding signal increased when Fab2 or Fab3 was injected over the complex, indicating these two Fabs do not compete with Fab1 for receptor binding. In addition, the different profiles of the Fab2 and Fab3 binding responses indicated these two Fabs bind the receptor with different kinetics. Complementing this mapping study, reputable antibody screening studies and kinetic analyses are described in references 280, 322, 301 and 338.

4. Small molecule interactions

Analysis of the pH-dependencies of the association and dissociation kinetics of HIV-1 protease inhibitors. Gossas T, Danielson UH. (2003) *J. Mol. Recognit.* **16**: 203–212.

Improvements in experimental design and data processing make it fairly routine to measure the binding of small molecules to macromolecular targets using biosensor technology. Danielson and co-workers' study of small-molecule HIV-1 protease inhibitors emphasizes the importance of determining rate constants (rather than simply the interaction affinity) to understand binding events.[774,788,812] For example, Gossas and Danielson measured how pH affects interaction rates for different structural classes of inhibitors.[788] Sensorgrams obtained for one inhibitor are shown in the main panel of Fig. 6. The high signal-to-noise responses obtained for this small molecule (635 Da) demonstrate the biosensor's ability to produce reliable binding responses even for low-molecular-mass compounds. The inset in Figure 6 shows a kinetic map of an inhibitor panel tested at three different pHs. While some compounds displayed little pH dependence, others displayed changes in either the association or dissociation rate, and a third group displayed significant changes in both rates. The inset also identifies interactions of similar affinities that actually have very different kinetics and therefore distinct binding mechanisms. Additional examples of high-quality characterizations of small molecules are found in references 779–782, 792 and 809.

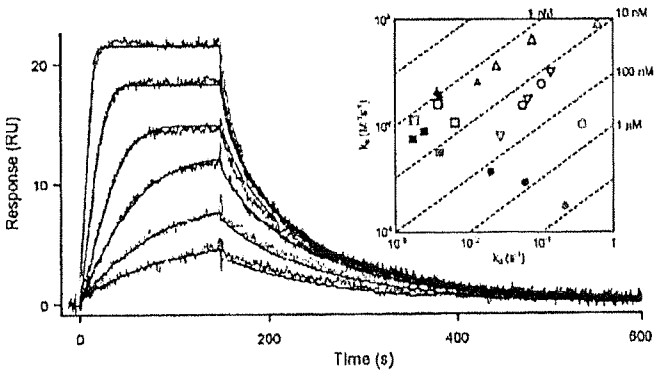

Figure 6. Main panel: kinetic analysis of a small-molecule sulfonamide inhibitor binding to HIV-1 protease. Overlaid black lines depict the fit of the data to the interaction model. Inset: plot of rate constants (k_a vs k_d) obtained for seven inhibitors tested at pH 4.1 (red), 5.1 (blue) and 7.4 (green) with dashed lines bracketing regions of similar affinities. Adapted from reference 788 with permission from John Wiley and Sons Ltd © 2003.

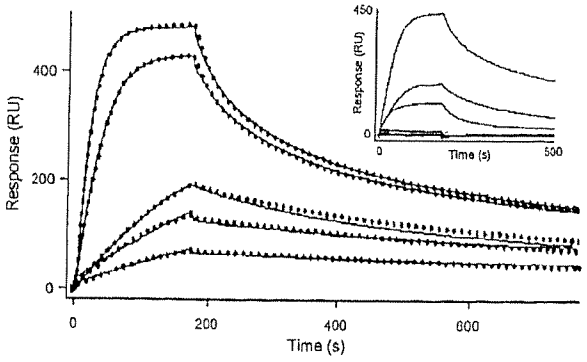

Figure 7. Main panel: kinetic analysis of soluble ricin toxin B-chain binding to an asialoganglioside surface (solid lines depict the fit of the interaction model). Inset: ricin toxin B-chain binding to seven different glycolipid surfaces. Adapted from reference 662 with permission from Elsevier Science © 2003.

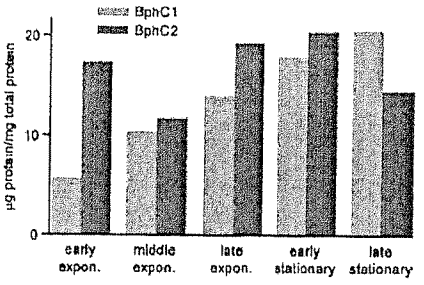

Figure 8. Monitoring expression levels of two proteins (BphC1 and BphC2) throughout the phases of cell culture growth. Adapted from reference 873 with permission from the American Society for Microbiology © 2003.

5. Lipid interactions

Investigating the interaction of the toxin ricin and its B-chain with immobilised glycolipids in supported phospholipids membranes by surface plasmon resonance. Gustafson L. (2003) *Colloids Surf. B* **30**: 13–24.

One significant advantage of the biosensor's flow cell/sensor chip arrangement is it can be used to mimic the solution–surface interface that occurs in membrane biology. In real time, the sensor can monitor how analytes bind to, and then embed into or transport across, immobilized lipid layers that model different membranes. For example, Gustafson used the biosensor to examine glycolipids both qualitatively and quantitatively. To identify the membrane components required for a successful interaction, ricin toxin was screened against lipid surfaces that varied in their carbohydrate contents (Fig. 7 inset) and promising interactions were re-examined in detail to determine rate and affinity constants (an example is shown in the main panel of Fig. 7). Using lipid layers that mimic cancer and normal cell membranes, Papo *et al.* confirmed that the mode of action for a new class of chemotherapeutic peptides involves preferentially binding to cancer cell membranes.[681,683] Taking a different approach, Whitesides and co-workers prepared a variety of mixed self-assembled monolayers (SAMs) on the sensor chip to identify and optimize coatings that can be applied to surfaces to make them resistant to protein adsorption.[670,680] Together, these three examples hint at the diversity of lipid and SAM studies that rely on biosensors.

6. Interactions in crude material

Substrate specificity and expression of three 2,3-dihydrobiphenyl 1,2-dioxygenases from *Rhodococcus globerulus* strain P6. McKay DB *et al.* (2003) *J. Bacteriol.* **185**: 2944–2951.

In 2003, the number of articles that described using the biosensor to detect and/or quantitate analytes in crude materials (such as serum, cell culture and food products) more than doubled compared with years past. Illustrating the latest developments in this promising biosensor application, McKay *et al.* designed an assay to track protein expression levels in cell extracts during different phases of culture growth. These researchers first constructed a calibration plot by testing purified BphC proteins binding to immobilized anti-BphC antibodies and then measured the binding responses generated when crude cell extracts were injected over the surface. Figure 8 illustrates how the expression levels of BphC1 and BphC2 differed during culture maturation. Further demonstrating the biosensor's utility in analyzing complex samples, Mobini *et al.* screened plasma panel to identify patients having antibodies against cardiac tissue proteins[828] and Choe *et al.*, using the biosensor as a protein purification tool, screened different buffer conditions to determine which conditions were optimal to extract recombinant proteins from *E. coli* exclusion bodies.[865] The work performed by these research groups provides the groundwork for developing next-generation assays that will require little, if any, pre-analysis sample purification, as well as better approximate the *in vivo* milieu.

7. Kinetic analysis

Analysis of an orf virus chemokine-binding protein: shifting ligand specificities among a family of poxvirus viroceptors. Seet BT *et al.* (2003) *Proc. Natl. Acad. Sci. USA* **100**: 15137–15142.

The ability to monitor binding events in real time without reagent labels is what sets biosensors apart from other interaction technologies. A kinetic analysis, however, requires careful experimental design and execution, as well as appropriate data processing, analysis, and interpretation. Figure 9 epitomizes a good kinetic analysis. In this experiment, Seet *et al.* immobilized the chemokine-binding protein (CBP) at a low density on the sensor chip surface, examined chemokine over a wide range of concentrations, and measured each concentration in triplicate. These researchers also demonstrated how to measure the dissociation rate for an extremely slowly dissociating complex. Since the binding signal for the eotaxin–CBP interaction shows no decay in the dissociation phase over the four minutes used in the initial kinetic analysis [Fig. 9(D), left panel], the highest concentration of this chemokine was retested with the dissociation phase monitored long enough to detect decay in the response intensity [Fig. 9(D), right

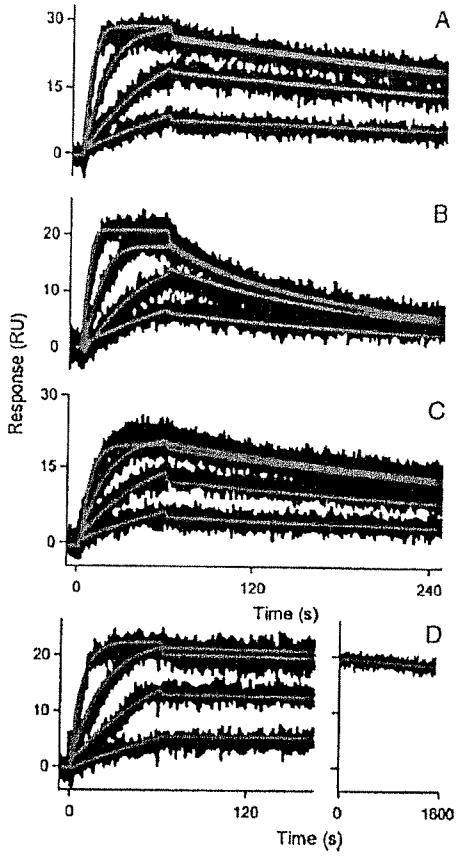

Figure 9. Kinetic analysis of a protein–protein interaction. (A–D) The responses generated by concentration series (1, 3, 9 and 27 nM) of four different chemokines flowed across an immobilized chemokine-binding protein; the sub-panel in (D) shows the dissociation of one chemokine/protein interaction (measured at 27 nM chemokine) for ~30 min. The gray lines depict the fit of each data set to a simple interaction model to yield kinetic and affinity parameters. Adapted from reference 196 with permission from the National Academy of Sciences USA © 2003.

panel]. Simultaneously fitting the two data sets shown in Fig. 9(D) yielded rate and affinity constants for this tight interaction: $k_a = 6 \times 10^6\,M^{-1}s^{-1}$, $k_d = 5 \times 10^{-5}\,s^{-1}$; $K_D = 8$ pM. Additional examples of high-quality kinetic analyses are shown in references 569, 619, 747 and 809.

8. Equilibrium analysis

Structure and ubiquitin binding of the ubiquitin-interacting motif. Fisher RD *et al.* (2003) *J. Biol. Chem.* 278: 28976–28984.

Another strong feature of the biosensor is its ability to monitor and quantitate low-affinity interactions. For example, Sundquist and coworkers tested ubiquitin binding to a panel of immobilized peptides to identify essential contact residues. The sensorgrams for one interaction are shown in Fig. 10(A) and the binding isotherms for six of the peptides are shown in Fig. 10(B). Although these interactions were weak, the analysis yielded reproducible responses for the low-affinity mutant peptides that could be fit to obtain binding constants approaching the mM range. References 167, 223, 448, 459 and 815 also include well-performed equilibrium analyses and references 201, 384, 389, 412 and 779 demonstrate the agreement between affinities determined by both kinetic and equilibrium analyses.

9. Competition analysis

Probing the interactions of phosphosulfomannans with angiogenic growth factors by surface plasmon resonance. Cochran S *et al.* (2003) *J. Med. Chem.* 46: 4601–4608.

Equilibrium dissociation constants can be determined directly as shown in Fig. 10, but can also be determined from competition studies. For example, Cochran *et al.* used this type of analysis to determine the affinities of oligosaccharide anti-tumor agents for the growth factors FGF-1, FGF-2, and VEGF (Fig. 11). Using an immobilized heparin surface to determine the concentration of free growth factor in solution, these researchers determined the optimal oligosaccharide chain length and degrees of phosphorylation and sulfation required to induce high-affinity binding. Using a similar assay, He *et al.* determined the solution-based

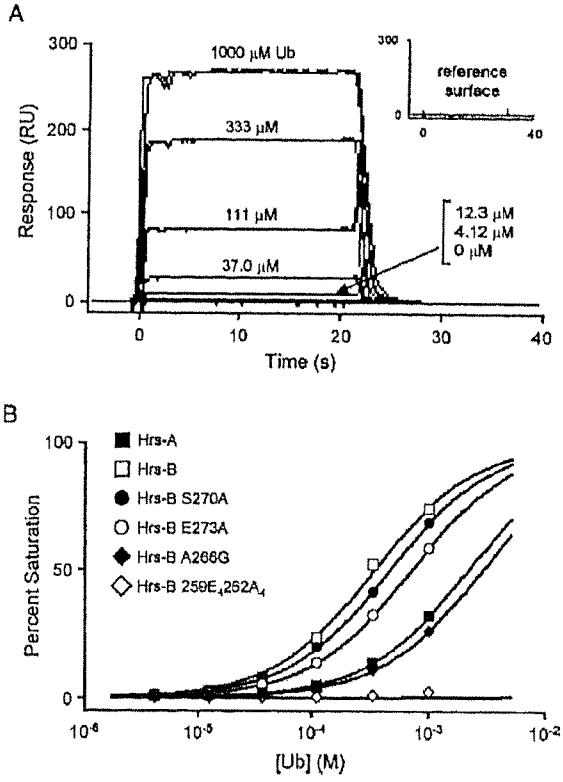

Figure 10. Equilibrium analysis of a protein–peptide interaction. (A) Responses for ubiquitin (Ub) in solution binding to an immobilized peptide, Hrs-B, which encompassed a Ub-interacting motif. (Inset: Ub injected over a reference surface.) Fitting the responses at equilibrium ($t = 5$–15 s) plotted vs Ub concentration to a simple binding isotherm yielded an interaction affinity of 291 ± 12 μM. (B) Isotherms for Ub binding to wild type and mutant peptides. Reproduced from reference 473 with permission from the American Society for Biochemistry and Molecular Biology © 2003.

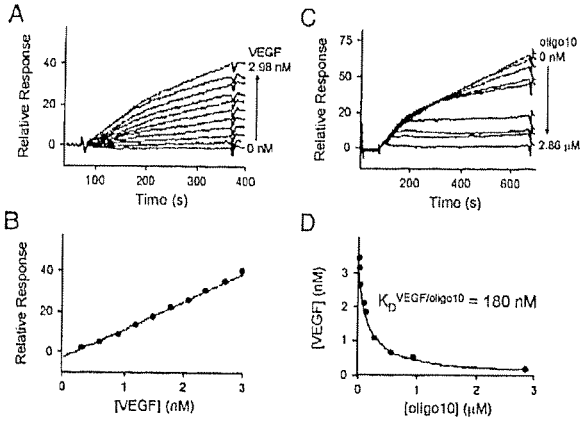

Figure 11. Solution competition analysis to determine the affinity of VEGF for oligosaccharide 10. (A) Sensorgrams obtained for a concentration series of VEGF binding to immobilized heparin. (B) Responses from (A) plotted vs VEGF concentration to yield the standard curve. (C) Sensorgrams obtained for VEGF (2.98 nM) binding to heparin as the concentration of oligo10 increases. (D) Free VEGF concentration plotted vs oligo10 concentration and fit to a simple binding isotherm to obtain the solution-phase affinity for the VEGF/oligo10 interaction. Adapted from reference 709 with permission from the American Chemical Society © 2003.

affinities constants for CoA/acylCoA dehydrogenase interactions to identify the key enzyme residues responsible for substrate specificity[792] and Carnahan *et al.* obtained the affinity for an antibody/antigen interaction (and complemented this competition analysis with a direct kinetic analysis performed in the opposite orientation).[251]

10. Ligand preparation

Kinetics and energetics of the binding between barley α-amylase/subtilisin inhibitor and barley α-amylase 2 analyzed by surface plasmon resonance and isothermal titration calorimetry. Nielsen PK *et al.* (2003) *Biochemistry* **42**: 1478–1487.

Nielsen *et al.* detailed a ligand immobilization method that is rapidly gaining popularity (also see references 78, 349, 441, 450 and 744). We refer to it as 'minimal biotinylation'. By adding a substoichiometric amount of biotinylating agent to the ligand solution, we favor modifying only a single residue on the ligand. It is an efficient yet gentle method to prepare an active, stable ligand surface because it avoids exposing the ligand to the low-pH, low-salt environment that is used during standard amine coupling. Minimal biotinylation is quick (requiring less than 1 h total) and straightforward (the steps are outlined in Fig. 12). In addition, it can be performed in standard buffers like HEPES-buffered saline and the variety of available EZLink™ biotinylating agents (of varying linker lengths and targeting different reactive group) makes this method chemically feasible for almost any system. We highly recommend trying this method the next time you have a ligand that loses activity when it is immobilized through standard amine coupling.

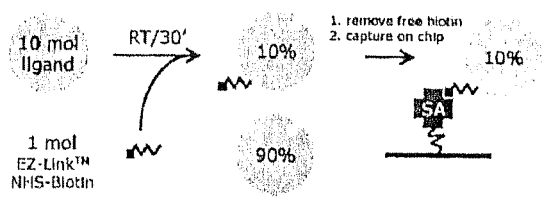

Figure 12. Schematic of minimal ligand biotinylation procedure. Ligand and biotin are mixed at a 10:1 ratio in buffer (pH ≈ 7) and allowed to react for 30 min at room temperature. To selectively immobilize biotinylated ligand, the mixture is then passed over a fast desalting column (e.g. Pharmacia® PD-10) to remove free biotin and then injected across a streptavidin (SA)-coated chip.

11. Ligand capture

Determination of the energetics governing the regulatory step in growth hormone-induced receptor homodimerization. Bernat B *et al.* (2003) *Proc. Natl. Acad. Sci. USA* **100**: 952–957.

Kossiakoff and co-workers used a ligand-capturing assay to characterize the two-step hormone-induced dimerization of human growth hormone receptor.[363,438] First, receptor was immobilized on the sensor chip surface, then the ligand (human growth hormone) was captured and, finally, receptor was injected over the receptor–ligand complex. Since the interaction could be fully disrupted by the regeneration conditions, the immobilized receptor surface was used to screen panels of mutants to identify residues in both the hormone and receptor that were essential for binding. Hormone–receptor pairs of interest were then further examined to obtain kinetic rate constants that described assembly of the trimolecular complex (one example is shown in Fig. 13). Although this analysis was complicated

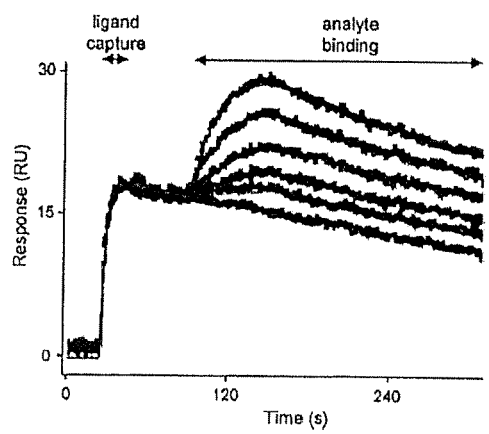

Figure 13. Kinetic analysis of human growth hormone receptor homodimerization. Hormone was first captured by immobilized receptor and then the kinetics of soluble receptor binding to the complex on the surface was measured. The grey lines depict the fit of the data to a simple interaction model that accounts for the slow dissociation of ligand from the surface. Adapted from reference 363 with permission from the National Academy of Sciences, USA © 2003.

by the dissociation of ligand from the surface during the analyte binding cycle, the kinetics of this interaction could be determined by applying a fitting model that accounted for the background decay.

Other researchers expanded on the theme of using the surface as a scaffold for molecular assembly. For example, Stenlund *et al.* developed a 'capture and reconstitution' method to examine membrane-associated receptors.[430] Chemokine receptors were first captured from crude cell preparations by immobilized antibodies and a lipid bilayer was then reconstituted on the surface to maintain the receptors' activities. Demonstrating the biosensor's contribution in physical science/engineering applications, Ryadnov *et al.* built and characterized stable ternary peptide complexes that serve as a model system for self-assembling nanoscale networks.[522]

12. Experiment description

Discovery of an inhibitor of a transcription factor using small molecule microarrays and diversity-oriented synthesis. Koehler AN *et al.* (2003) *J. Am. Chem. Soc.* **125**: 8420–8421.

Koehler *et al.* included an exceptionally detailed experimental section in the supporting information that accompanies their article describing small-molecule transcription factor inhibitors. These authors outlined how to maintain a well-running biosensor, as well as how to equilibrate the instrument fully when changing buffers. In addition, they explained the steps involved in the immobilization of anti-GST and capture of ligand, the construction of a calibration curve to correct for the excluded-volume effect of the co-solvent dimethylformamide, and the binding analysis of the analyte concentration series. Including details like these make it easy for other biosensor users to replicate the experiment or adapt the methods to other applications, as well as to determine the expertise of the user and identify potential artifacts that may complicate the analysis.

13. Data presentation

Thermodynamic analysis of degenerate recognition by the NKG2D immunoreceptor: not induced fit but rigid adaptation. McFarland BJ, Strong RK (2003) *Immunity* **19**: 803–812.

As we have said before, publishing figures of primary data and fits is critical. Figure 14 exemplifies the type of figures we like to see when kinetic and/or affinity parameters are reported. Simply from looking at these two panels, we can evaluate the quality of the experiment, as well as the mechanistic differences between the two interactions. In the kinetic analysis [Fig. 14(A)], we see significant curvature in the association phase of the highest responses and measurable decay in the dissociation phase. In the equilibrium analysis [Fig. 14(B)], the analyte concentrations span the reported K_D and a plateau in response (indicating equilibrium was achieved) is evident in each sensorgram. Additional examples of informative figures from well-performed experiments are found in references 81, 134, 212, 229, 264, 338, 349, 362, 425, 448, 561, 619 and 747.

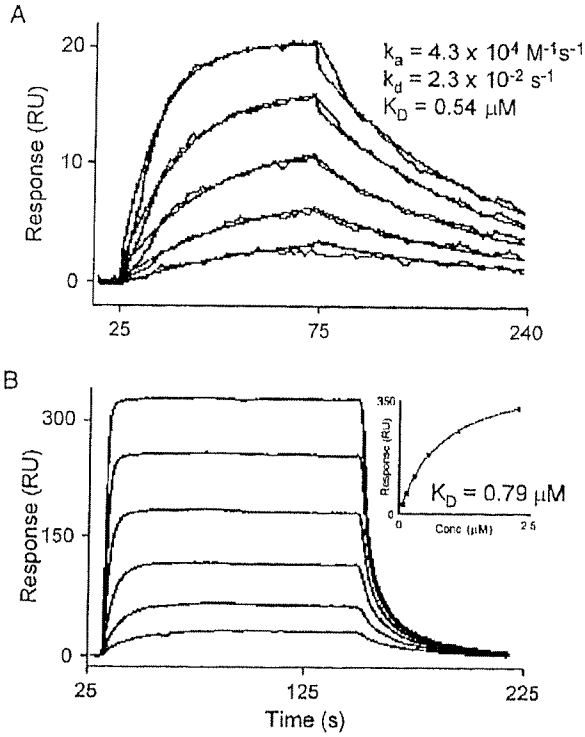

Figure 14. Characterization of immunoreceptor NKG2D binding to its ligands, MIC-A and MIC-B. (A) Kinetic analysis of 0.16–2.5 μM NKG2D binding to immobilized MIC-A. The overlaid lines represent the fit of the data to a simple 1:1 interaction model. (B) Equilibrium analysis of 0.06–2.3 μM NKG2D binding to immobilized MIC-B. The inset shows the responses at equilibrium ($t \approx 125$ s) plotted vs the injected NKG2D concentrations and fit to a simple binding isotherm. Adapted from reference 412 with permission from Elsevier © 2003.

PRESENTING INFORMATIVE FIGURES

Whenever possible, it is best to present data as figures. It is much easier to interpret trends and extract information from graphical forms than from tables. For example, in Fig. 1 we present the distribution of papers published from different countries around the world and by states within the USA. This graphical representation makes it easy to interpret a large set of information. A less appealing way of presenting this same data would have been to list the countries and states in a table.

Presenting biosensor data in a graphical form is also extremely important. Compared with a table of numbers with chi-square values, a figure of primary response data allows the reader to judge quickly the quality of the data, as well as its interpretation. Some 70% of the year 2003 articles included at least one figure of primary data. While this is a tremendous improvement over years past (in which only ~40% of articles included a figure), it means that we cannot gauge the quality of data described in the other 30%. Even more unfortunately, only 25% of the quantitative analyses showed both data and fits and many of these were of mediocre quality. For example, only 8% (28 out of the 351 articles published in 2003) that reported kinetic

rate constants included an information-rich figure of sensorgrams overlaid with a simple fit. The remaining 92% of kinetic analyses included either figures of data that were highly suspect or no figures of biosensor data whatsoever, so we were unable to judge the merit of the experiment.

The figures we have included from the spotlighted articles are excellent examples of informative, well-presented figures. Look at the biosensor data in Fig. 3 again. It is easy to compare the reproducibility of the responses within an experiment, as well as between experimenters. It is also possible to judge the quality of the fit based on how well the modeled data (red lines) overlay the experimental data (black lines). Now look at the data in Fig. 4. Here are eight different forms of the protein studied under two different conditions. It is very easy to interpret visually which mutations and buffer conditions had an effect on the binding interaction and which did not.

The binding profiles recorded from a biosensor can tell you a lot about a system even without fitting the data to an interaction model. The response for a simple 1:1 interaction, in which two molecules must come together to form a complex, should be single exponential in the association and dissociation phase. The binding responses modeled in Fig. 15 are examples of four simple interactions that differ in their kinetics but are all described by single exponentials. In Fig. 16, we present deviations from a single exponential curve that we commonly see in the literature. We group these deviations into four general classes: instrument artifacts, poor quality reagents, poor experimental design, or complex biology.

Figure 16(A) and (B) are examples of responses that result from mass transport effects. In order for an analyte to bind to a ligand on the sensor surface it must first diffuse down to the surface. If the binding rate is faster than the diffusion rate, then a concentration gradient will form in the flow cell and the interaction will be limited by the diffusion event. When this happens, the binding response will be linear in the initial phases of the reaction [Fig. 16(A)]. In some cases, by reducing the surface capacity or increasing the flow rate it is possible to eliminate the mass transport effect. Otherwise, it is appropriate to fit the data using a model that accounts for the mass transport step.[779] Figure 16(B) is an example of binding data that are so highly limited by mass transport that concentration gradients develop within the dextran layer at the sensor surface. When this occurs, the binding response has a sigmoidal shape. Modeling these types of data becomes very challenging and it is often best to redesign the experiment to minimize the mass transport event.

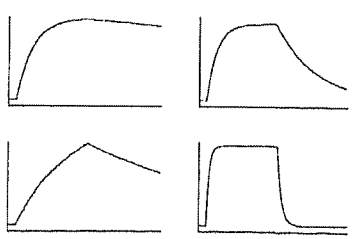

Figure 15. Examples of single-exponential profiles for simple binding interactions.

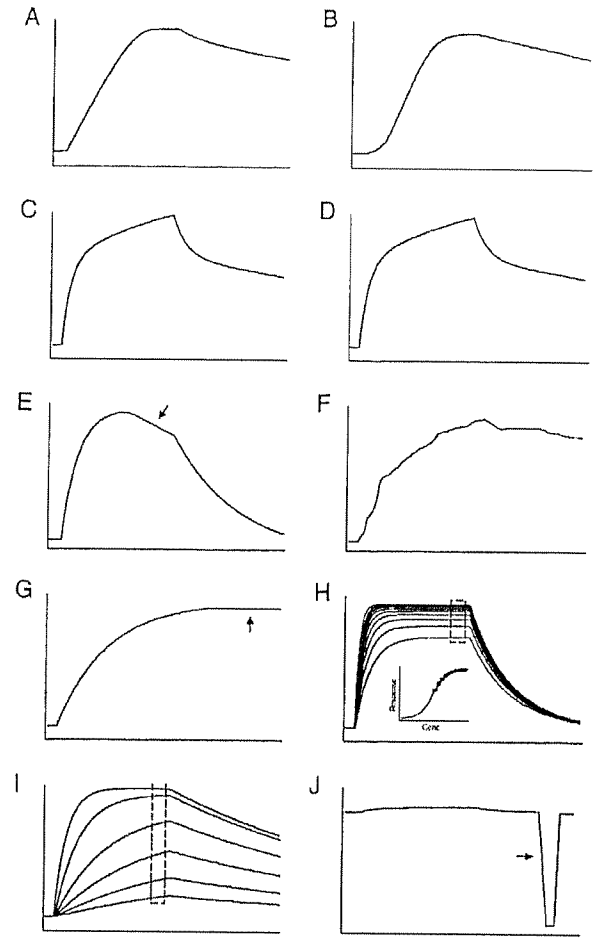

Figure 16. Binding responses that are not described by a simple 1:1 interaction model or exhibit problems relating to instrument function, assay design, and data presentation. (A) Profile of a 1:1 interaction influenced by mass transport. (B) Sigmoidal profile produced by a highly mass transported-limited interaction. (C) Complex profile described by heterogeneous binding model. (D) Complex profile described by a conformational change model. (E) Sensorgram showing signal decay at the end of the association phase (marked by the arrow) due to sample plug dispersion. (F) Bumpy sensorgram produced by impure reagents or a fouled instrument. (G) Sensorgram lacking sufficient decay in the dissociation phase (marked by the arrow) to measure k_d. (H) Main panel: sensorgrams obtained for a narrow analyte concentration series. Inset: Response intensities at the end of the association phase (enclosed by the box in the main panel) plotted on a log scale against analyte concentration. (I) Sensorgrams inappropriately used for an equilibrium analysis even though some of the responses have not reached equilibrium by the end of the association phase (enclosed by the box). (J) Sensorgram scaled with respect to regeneration pulse (marked by the arrow), which obscures the signal produced by the binding interaction.

Two other sensorgram profiles that commonly appear in the literature are depicted in Fig. 16(C,D). These binding profiles are composed of multiple exponentials. Typically the association phase never reaches equilibrium. It is striking to see the number of publications that attribute this deviation from a simple model as due to some interesting complex mechanism (conformational changes, allosteric interactions, or multiphasic binding events). Instead, a vast

majority of the time the deviation is produced by heterogeneity in either the ligand or analyte (most often it is in the ligand and is induced by the immobilization process). Regardless of the cause, it is very difficult to resolve binding constants from these types of data sets. For example, the data shown in Fig. 16(C,D) were generated for two different types of reaction mechanisms (heterogeneity and conformational change, respectively), but to the eye and to the fitting programs these data sets look identical. Both models will fit each of these data sets equally well. We often find investigators reporting the results from fitting a conformational change model to these types of data and claiming they have uncovered some interesting binding mechanism. While it is true that there could be a number of macromolecular interactions that involve intricate mechanisms, poor experimental design and poor quality reagents are more than likely the cause of complex binding profiles.

Figure 16(E,F) depicts sensorgrams that indicate mechanical and/or sample issues. For example, the decay in response at the end of the association phase in Fig. 16(E) is sometimes interpreted as resulting from a conformational change, but more than likely it is caused by dispersion of the sample plug. The injected sample is being diluted as it passes through the flow system. This could be an indication that the fluidic cartridge needs cleaning/replacing or the sample-handling valve is not functioning properly. Profiles like the 'bumpy' sensorgram shown in Fig. 16(F) are often produced by aggregates in the analyte, particulates in the running buffer, or an instrument that needs to be cleaned. Centrifuging the analyte samples, filtering and degassing the running buffer, and performing the 'desorb' command (for Biacore instruments) can help correct this problem.

The sensorgrams shown in Fig. 16(G,H,I) arise from experimental design problems. In Fig. 16(G), we see no decay in the response during the dissociation phase and therefore a k_d determined from this sensorgram would be unreliable. As Seet *et al.* demonstrated [as shown in Fig. 9(D) and reference 196], dissociation of the complex should be monitored until significant decay in the response is observed. A general rule is that if your eye can see the decay (and the decay is reproducible across repeated experiments) then the dissociation rate can be reliably determined. With Biacore instruments, it is possible to monitor the dissociation phase for up to 24 h, which sets the limit on the slowest determinable k_d at $\sim 1 \times 10^{-6}\,s^{-1}$.

Figure 16(H) shows the binding responses for a very narrow concentration range of analyte. We refer to this example as the 'pearls on a string' approach because the responses are bunched together when plotted vs concentration [Fig. 16(H) inset]. While this may be fine in the fashion world, it is a faux pas from a statistical standpoint. To rigorously analyze an interaction requires testing the analyte over a wide concentration range—ideally, from concentrations that produce little or no apparent binding to concentrations that saturate the ligand surface. Expanding the analysis shown in Fig. 16(H) to include more dilute samples would be simple since it consumes little material. Although the example we have shown here is of an equilibrium analysis, testing a wide range of analyte concentrations is critical in a kinetic analysis as well.

Figure 16(I) is an example of measuring the binding interaction across a wide range of concentrations, which is good except that we all too often see investigators using this type of data to perform an equilibrium analysis. The problem here is that the responses for all of the analyte concentrations have not reached equilibrium. To obtain useable data, the investigator would need to extend the time of the association phase.

Figure 16(J) illustrates a common data presentation issue. In this example, the entire binding cycle is being presented to the reader, including the dip due to the regeneration pulse. On this scale, it becomes difficult to see the relevant information contained in the association and dissociation phase. While it is important to confirm that surface regeneration was complete, it is better demonstrated by showing the overlay of replicate analyte injections.[196,436,669,779]

As a rule, if you want the reader to feel confident in the rate constants you report from biosensor data, you need to show the data and fit since the data reveal the quality of the experiment and the fit justifies the interpretation of the interaction. For a kinetic analysis, this means including a figure of the binding responses for an analyte concentration series overlaid with the model fit, for equilibrium and inhibition/competition analyses the analyte concentration series and binding isotherm should be shown, and for a concentration analysis it would be good to see at least a subset of the sensorgrams obtained for the standards and samples, as well as the calibration curve. There is clearly room for improvement in how biosensor data are presented in the literature.

SUMMARY

Based on the number of disappointingly low-quality biosensor articles we read this past year, it is not surprising that the scientific community in general still regards data obtained from this technology with some suspicion. This is regrettable since the biosensor's capabilities have been proven. We are excited, however, about what biosensors can offer in the study of almost any biologicial system and want this technology to be used to its full potential. We are also confident that with good reagents and attention to detail most biosensor users can obtain high-quality data. To illustrate this point, we spotlighted thirteen important contributions that should advance the biosensor's application and its reputation.

REFERENCES

Reviews

1. Anderluh G, Maček P, Lakey JH. Peeking into a secret world of pore-forming toxins: membrane binding processes studied by surface plasmon resonance. *Toxicon* 42: 225–228.

2. Baeumner AJ. 2003. Biosensors for environmental pollutants and food contaminants. *Anal. Bioanal. Chem.* 377: 434–445.

3. Becker GW, Knierman MD, Shiyanov P, Hale JE. 2003. Proteomics. In *Handbook of Industrial Cell Culture: Mammalian, Microbial, and Plant Cells*, Vinci VA, Parekh SR (eds). Humana Press: Totowa, NJ; 321–348.
4. Bennett PB, Guthrie HRE. 2003. Trends in ion channel drug discovery: advances in screening technologies. *Trends Biotechnol.* **21**: 563–569.
5. Bohn PW. 2003. Peptide- and protein-based biomolecular assemblies: physical and chemical characterization for optimal function. In *Biomolecular Films: Design, Function, and Applications*, Rusling JF (ed.). Marcel Dekker: New York; 163–212.
6. Bozonnet S, Kim T-J, Bønsager BC, Kramhøft B, Nielsen PK, Bak-Jensen KS, Svensson B. 2003. Engineering of barley α-amylase. *Biocatal. Biotransform.* **21**: 209–214.
7. Campàs M, O'Sullivan C. 2003. Layer-by-layer biomolecular assemblies for enzyme sensors, immunosensing, and nanoarchitectures. *Anal. Lett.* **36**: 2551–2569.
8. Chen T, MacDonald N, Wingard J. 2003. Analyzing biomolecular binding using surface plasmon resonance. *PharmaGenomics* **3**: 44–47.
9. Coleman RA, Clark KL. 2003. Target validation using human tissue: from gene expression to function. *TARGETS* **2**: 58–64.
10. Cooper MA. 2003. Label-free screening of biomolecular interactions. *Anal. Bioanal. Chem.* **377**: 834–842.
11. Cooper MA. 2003. Biosensor profiling of molecular interactions in pharmacology. *Curr. Opin. Pharmac.* **3**: 557–562.
12. D'Orazio P. 2003. Biosensors in clinical chemistry. *Clin. Chim. Acta* **334**: 41–69.
13. Davis SJ, Ikemizu S, Evans EJ, Fugger L, Bakker TR, van der Merwe PA. 2003. The nature of molecular recognition by T cells. *Nat. Immunol.* **4**: 217–224.
14. Duverger E, Frison N, Roche A-C, Monsigny M. 2003. Carbohydrate-lectin interactions assessed by surface plasmon resonance. *Biochimie* **85**: 167–179.
15. Englebienne P, Van Hoonacker A, Verhas M. 2003. Surface plasmon resonance: principles, methods and applications in biomedical sciences. *Spectroscopy* **17**: 255–273.
16. Englebienne P, Van Hoonacker A, Verhas M, Khlebtsov NG. 2003. Advances in high-throughput screening: biomolecular interaction monitoring in real-time with colloidal metal nanoparticles. *Comb. Chem. High Throughput Screen.* **6**: 777–787.
17. Escuder-Gilabert L, Martínez-Pla JJ, Sagrado S, Villanueva-Camañas RM, Medina-Hernández MJ. 2003. Biopartitioning micellar separation methods: modelling drug absorption. *J. Chromatogr. B* **797**: 21–35.
18. Gilbert J, Vargas EA. 2003. Advances in sampling and analysis for aflatoxins in food and animal feed. *J. Toxicol.* **22**: 381–422.
19. Glökler J, Angenendt P. 2003. Protein and antibody microarray technology. *J. Chromatogr. B* **797**: 229–240.
20. Herzyk DJ. 2003. The immunogenicity of therapeutic cytokines. *Curr. Opin. Mol. Ther.* **5**: 167–171.
21. Homola J. 2003. Present and future of surface plasmon resonance biosensors. *Anal. Bioanal. Chem.* **377**: 528– 539.
22. Howbrook DN, van der Valk AM, O'Shaughnessy MC, Sarker DK, Baker SC, Lloyd AW. 2003. Developments in microarray technologies. *Drug Discov. Today* **8**: 642–651.
23. Jain KK. 2003. Current status of molecular biosensors. *Med. Device Technol.* **14**: 10–15.
24. Jona G, Snyder M. 2003. Recent developments in analytical and functional protein microarrays. *Curr. Opin. Mol. Ther.* **5**: 271–277.
25. Killard AJ, Smyth MR. 2003. Biosensors. In *Biomolecular Films: Design, Function, and Applications*, Rusling JF (ed.). Marcel Dekker: New York; 451–497.
26. Konthur Z, Crameri R. 2003. High-throughput applications of phage display in proteomic analyses. *TARGETS* **2**: 261–270.
27. Kramer K, Hock B. 2003. Recombinant antibodies for environmental analysis. *Anal. Bioanal. Chem.* **377**: 417–426.
28. Leonard P, Hearty S, Brennan J, Dunne L, Quinn J, Chakraborty T, O'Kennedy R. 2003. Advances in biosensors for detection of pathogens in food and water. *Enzyme Microbial Technol.* **32**: 3–13.
29. Lidstrom ME, Meldrum DR. 2003. Life-on-a-chip. *Nat. Rev. Microbiol.* **1**: 158–164.
30. Löfås S. 2003. SPRing screening. *Mod. Drug Discov.* **May**: 47–49.
31. Luzi E, Minunni M, Tombelli S, Mascini M. 2003. New trends in affinity sensing: aptamers for ligand binding. *Trends Anal. Chem.* **22**: 810–818.
32. MacKenzie CR, Jennings HJ. 2003. Characterization of polysaccharide conformational epitopes by surface plasmon resonance. *Meth. Enzymol.* **363**: 340–354.
33. Malhotra BD, Chaubey A. 2003. Biosensors for clinical diagnostics industry. *Sensors Actuators B* **91**: 117–127.
34. Minunni M. 2003. Biosensors based on nucleic acid interaction. *Spectroscopy* **17**: 613–625.
35. Mozsolits H, Thomas WG, Aguilar M-I. 2003. Surface plasmon resonance spectroscopy in the study of membrane-mediated cell signalling. *J. Pept. Sci.* **9**: 77–89.
36. Myszka DG, Rich RL. 2003. SPR's high impact on drug discovery: resolution, throughput, and versatility. *Drug Discov. World* **Spring**: 49–55.
37. Nakamura H, Karube I. 2003. Current research activity in biosensors. *Anal. Bioanal. Chem.* **377**: 446–468.
38. Nedelkov D, Nelson RW. 2003. Surface plasmon resonance mass spectrometry: recent progress and outlooks. *Trends Biotechnol.* **21**: 301–305.
39. Ng JH, Ilag LL. 2003. Biochips beyond DNA: technologies and applications. *Biotech. Annu. Rev.* **9**: 1–149.
40. Pendley C, Schantz A, Wagner C. 2003. Immunogenicity of therapeutic monoclonal antibodies. *Curr. Opin. Mol. Ther.* **5**: 172–179.
41. Phizicky E, Bastiaens PIH, Zhu H, Snyder M, Fields S. 2003. Protein analysis on a proteomic scale. *Nature* **422**: 208–215.
42. Rich RL, Myszka DG. 2003. A survey of the year 2002 commerical optical biosensor literature. *J. Mol. Recognit.* **16**: 351–382.
43. Rich RL, Myszka DG. 2003. Spying on HIV with SPR. *Trends Microbiol.* **11**: 124–133.
44. Rinken T. 2003. Determination of kinetic constants and enzyme activity from a biosensor transient signal. *Anal. Lett.* **36**: 1535–1545.
45. Sharma SK, Sehgal N, Kumar A. 2003. Biomolecules for development of biosensors and their applications. *Curr. Appl. Phys.* **3**: 307–316.
46. Sheehan A, Quinn JG, Daly SJ, Dillon P, O'Kennedy R. 2003. The development of novel miniaturized immuno-sensing devices: a review of a small technology with a large future. *Anal. Lett.* **36**: 511–537.
47. Swanson SJ. 2003. New technologies for the detection of antibodies to therapeutic proteins. *Dev. Biol. (Basel)* **112**: 127–133.
48. Ulber R, Frerichs J-G, Beutel S. 2003. Optical sensor systems for bioprocess monitoring. *Anal. Bioanal. Chem.* **376**: 342–348.
49. van der Merwe PA, Davis SJ. 2003. Molecular interactions mediating T cell antigen recognition. *Annu. Rev. Immunol.* **21**: 659–684.
50. Van Regenmortel MHV. 2003. Improving the quality of BIACORE-based affinity measurements. *Dev. Biol. (Basel)* **112**: 141–151.
51. Velasco-Garcia MN, Mottram T. 2003. Biosensor technology addressing agricultural problems. *Biosystems Eng.* **84**: 1–12.
52. Vo-Dinh T, Allain L. 2003. Biosensors for medical applications. In *Biomed. Photonics Handbook*, Vo-Dinh T (ed.). CRC Press: Boca Raton, FL; 1–39.
53. von der Haar T, McCarthy JEG. 2003. Studying the assembly of multicomponent protein and ribonucleoprotein complexes using surface plasmon resonance. *Methods* **29**: 167–174.
54. Wadhwa M, Bird C, Digler P, Gaines-Das R, Thorpe R. 2003. Strategies for detection, measurement and characterization of unwanted antibodies induced by therapeutic biologicals. *J. Immunol. Meth.* **278**: 1–17.
55. Wang S, Boussaad S, Tao NJ. 2003. Surface plasmon resonance spectroscopy: applications in protein adsorption and electrochemistry. In *Biomolecular Films: Design, Function, and Applications*, Rusling JF (ed.). Marcel Dekker: New York; 213–251.
56. Weller M. 2003. Classification of protein microarrays and related techniques. *Anal. Bioanal. Chem.* **375**: 15–17.

57. Willis RC. 2003. Protein chips: bound to deliver. *Today's Chem. Work* Jan: 29–33.
58. Winzor DJ. 2003. Surface plasmon resonance as a probe of protein isomerization. *Anal. Biochem.* **318**: 1–12.
59. Zhu H, Bilgin M, Snyder M. 2003. Proteomics. *Annu. Rev. Biochem.* **72**: 783–812.
60. Zhu H, Snyder M. 2003. Protein chip technology. *Curr. Opin. Chem. Biol.* **7**: 55–63.
61. Zieziulewicz TJ, Unfricht DW, Hadjout N, Lynes MA, Lawrence DA. 2003. Shrinking the biologic world—nanobiotechnologies for toxicology. *Toxicol. Sci.* **74**: 235–244.

Methods

62. Alam SM, Gascoigne NRJ. 2003. Binding kinetics of superantigen with TCR and MHC class II. *Meth. Mol. Biol.* **214**: 65–85.
63. Hahnefeld C, Drewianka S, Herberg FW. 2003. Determination of kinetic data using surface plasmon resonance biosensors. *Meth. Mol. Biol.* **94**: 299–320.
64. Kapoor M, Thomas CJ, Bachhawat-Sikder K, Sharma S, Surolia A. 2003. Exploring kinetics and mechanism of protein-sugar recognition by surface plasmon resonance. *Meth. Enzymol.* **362**: 312–329.
65. Rucker J. 2003. Optical biosensor assay using retroviral receptor pseudotypes. *Meth. Mol. Biol.* **228**: 317–328.
66. Sota H, Lee RT, Lee YC, Sinohara Y. 2003. Quantitative lectin-carbohydrate interaction analysis on solid-phase surfaces using biosensor based on surface plasmon resonance. *Meth. Enzymol.* **362**: 330–340.
67. Wong C-H, Liang F-S. 2003. Surface plasmon resonance study of RNA-aminoglycoside interactions. *Meth. Enzymol.* **362**: 340–353.

Biacore

Proteins.

68. Adkins HB, Blanco C, Schiffer SG, Rayhorn P, Zafari M, Cheung AE, Orozco O, Olson D, De Luca A, Chen LL, Miatkowski K, Benjamin C, Normanno N, Williams KP, Jarpe M, LePage D, Salomon D, Sanicola M. 2003. Antibody blockade of the Cripto CFC domain suppresses tumor cell growth *in vivo*. *J. Clin. Invest.* **112**: 575–587.
69. Ahmed S, Yamamoto K, Sato Y, Ogawa T, Herrmann A, Higashi S, Miyazaki K. 2003. Proteolytic processing of IGFBP-related protein-1 (TAF/angiomodulin/mac25) modulates its biological activity. *Biochem. Biophys. Res. Commun.* **310**: 612–618.
70. Aktimur A, Gabriel MA, Gailani D, Toomey JR. 2003. The factor IX γ-carboxyglutamic acid (Gla) domain is involved in interactions between factor IX and factor XIa. *J. Biol. Chem.* **278**: 7981–7987.
71. Backer MV, Gaynutdinov TI, Gorshkova II, Crouch RJ, Hu T, Aloise R, Arab M, Przekop K, Backer JM. 2003. Humanized docking system for assembly of targeting drug delivery complexes. *J. Control. Release* **89**: 499–511.
72. Bannert N, Vollhardt K, Asomuddinov B, Haag M, König H, Norley S, Kurth R. 2003. PDZ domain-mediated interaction of interleukin-16 precursor proteins with myosin phosphatase targeting subunits. *J. Biol. Chem.* **278**: 42190–42199.
73. Bawumia S, Barboni EAM, Menon RP, Hughes RC. 2003. Specificity of interactions of galectin-3 with Chrp, a cysteine-and histidine-rich cytoplasmic protein. *Biochimie* **85**: 189–194.
74. Benabdelhak H, Kiontke S, Horn C, Ernst R, Blight MA, Holland IB, Schmitt L. 2003. A specific interaction between the NBD of the ABC-transporter HlyB and a C-terminal fragment of its transport substrate haemolysin A. *J. Mol. Biol.* **327**: 1169–1179.
75. Bergmann S, Wild D, Diekmann O, Frank R, Bracht D, Chhatwal GS, Hammerschmidt S. 2003. Identification of a novel plasmin(ogen)-binding motif in surface displayed α-enolase of *Streptococcus pneumoniae*. *Mol. Microbiol.* **49**: 411–423.
76. Bignone PA, Baines AJ. 2003. Spectrin αII and βII isoforms interact with high affinity at the tetramerization site. *Biochem. J.* **374**: 613–624.
77. Blom AM, Kask L, Ramesh B, Hillarp A. 2003. Effects of zinc on factor I cofactor activity of C4b-binding protein and factor H. *Arch. Biochem. Biophys.* **418**: 108–118.
78. Bønsager BC, Præterius-Ibba M, Nielsen PK, Svensson B. 2003. Purification and characterization of the β-trefoil fold protein barley α-amylase/subtilisin inhibitor overexpressed in *Escherichia coli*. *Protein Express. Purif.* **30**: 185–193.
79. Bovenschen N, Boertjes RC, van Stempvoort G, Voorberg J, Lenting PJ, Meijer AB, Mertens K. 2003. Low density lipoprotein receptor-related protein and factor IXa share structural requirements for binding to the A3 domain of coagulation Factor VIII. *J. Biol. Chem.* **278**: 9370–9377.
80. Brännström K, Segerman B, Gullberg M. 2003. Molecular dissection of GTP exchange and hydrolysis within the ternary complex of tubulin heterodimers and Op18/stathmin family members. *J. Biol. Chem.* **278**: 16651–16657.
81. Brunetti CR, Paulose-Murphy M, Singh R, Qin J, Barrett JW, Tardivel A, Schneider P, Essani K, McFadden G. 2003. A secreted high-affinity inhibitor of human TNF from Tanapox virus. *Proc. Natl. Acad. Sci. USA* **100**: 4831–4836.
82. Burns LL, Canaves JM, Pennypacker JK, Blumenthal DK, Taylor SS. 2003. Isoform specific differences in binding of a dual-specificity A-kinase anchoring protein to type I and type II regulatory subunits of PKA. *Biochemistry* **42**: 5754–5763.
83. Cao C, Leng Y, Li C, Kufe D. 2003. Functional interaction between the c-Abl and Arg protein-tyrosine kinases in the oxidative stress response. *J. Biol. Chem.* **278**: 12961–12967.
84. Cavada BS, da Silva LIMM, Ramos MV, Galvani FR, Grangeiro TB, Leite KB, Assreuy AMS, Cajazeiras JB, Calvete JJ. 2003. Seed lectin from *Pisum arvense*: isolation, biochemical characterization and amino acid sequence. *Protein Pept. Lett.* **10**: 607–617.
85. Chan BP, Chilkoti A, Reichert WM, Truskey GA. 2003. Effect of streptavidin affinity mutants on the integrin-independent adhesion of biotinylated endothelial cells. *Biomaterials* **24**: 559–570.
86. Charles CH, Luo GX, Kohlstaedt LA, Morantte IG, Gorfain E, Cao L, Williams JH, Fang F. 2003. Prevention of human rhinovirus infection by multivalent Fab molecules directed against ICAM-1. *Antimicrob. Agents Chemother.* **47**: 1503–1508.
87. Chen J, Ni H, Sun J, Weng G. 2003. G protein $\beta_1\gamma_2$ subunits purification and their interaction with adenylyl cyclase. *Sci. China, Ser. C* **46**: 212–223.
88. Chesnokova LS, Slepenkov SV, Protasevich II, Sehorn MG, Brouillette CG, Witt SN. 2003. Deletion of DnaK's IId strengthens binding to the nucleotide exchange factor, GrpE: a kinetic and thermodynamic analysis. *Biochemistry* **42**: 9028–9040.
89. Cheung P-Y, Fong C-C, Ng K-T, Lam W-C, Leung Y-C, Tsang C-W, Yang M, Wong M-S. 2003. Interaction between pyridoxal kinase and pyridoxal-5-phosphate-dependent enzymes. *J. Biochem.* **134**: 731–738.
90. Cohen R, Elferink LA, Atlas D. 2003. The C2A domain of synaptotagmin alters the kinetics of voltage-gated Ca^{2+} channels $Ca_v1.2$ (Lc-type) and $Ca_v2.3$ (R-type). *J. Biol. Chem.* **278**: 9258–9266.
91. Collins BM, Cubeddu L, Naidoo N, Harrop SJ, Kornfeld GD, Dawes IW, Curmi PMG, Mabbutt BC. 2003. Homomeric ring assemblies of eukaryotic Sm proteins have affinity for both RNA and DNA. *J. Biol. Chem.* **278**: 17291–17298.
92. Colombo K, Grill SW, Kimple RJ, Willard FS, Siderovski DP, Gönczy P. 2003. Translation of polarity cues into asymmetric spindle positioning in *Caenorhabditis elegans* embryos. *Science* **300**: 1957–1961.
93. Comoletti D, Flynn R, Jennings LL, Chubykin A, Matsumura T, Hasegawa H, Südhof TC, Taylor P. 2003. Characterization of the interaction of a recombinant soluble neuroligin-1 with neurexin-1β. *J. Biol. Chem.* **278**: 50497–50505.
94. Cunnea PM, Miranda-Vizuete A, Bertoli G, Simmen T, Damdimopoulos AE, Hermann S, Leinonen S, Huikko MP, Gustafsson J-Å, Sitia R, Spyrou G. 2003. ERdj5, an endoplasmic reticulum (ER)-resident protein containing DnaJ and thiore-

doxin domains, is expressed in secretory cells or following ER stress. *J. Biol. Chem.* **278**: 1059–1066.
95. Cwiklinska H, Mycko MP, Luvsannorov O, Walkowiak B, Brosnan CF, Raine CS, Selmaj KW. 2003. Heat shock protein 70 associations with myelin basic protein and proteolipid protein in multiple sclerosis brains. *Int. Immun.* **15**: 241–249.
96. Dekker RJ, Pannekoek H, Horrevoets AJ. 2003. A steadystate competition model describes the modulating effects of thrombomodulin on thrombin inhibition by plasminogen activator inhibitor-1 in the absence and presence of vitronectin. *Eur. J. Biochem.* **270**: 1942–1951.
97. Delorme V, Cayla X, Faure G, Garcia A, Tardieux I. 2003. Actin dynamics is controlled by a casein kinase II and phosphatase 2C interplay on *Toxoplasma gondii* toxofilin. *Mol. Biol. Cell* **14**: 1900–1912.
98. Demeule M, Bertrand Y, Michaud-Levesque J, Jodoin J, Rolland Y, Gabathuler R, Beliveau R. 2003. Regulation of plasminogen activation: a role for melanotransferrin (p97) in cell migration. *Blood* **102**: 1723–1731.
99. Dionne I, Nookala RK, Jackson SP, Doherty AJ, Bell SD. 2003. A heterotrimeric PCNA in the hyperthermophilic archaeon *Sulfolobus solfataricus*. *Mol. Cell* **11**: 275–282.
100. Dolphin A. 2003. G protein modulation of voltage-gated calcium channels. *Pharmac. Rev.* **55**: 607–627.
101. Dong J-F, Moake JL, Bernardo A, Fujikawa K, Ball C, Nolasco L, López JA, Cruz MA. 2003. ADAMTS-13 metalloprotease interacts with the endothelial cell-derived ultra-large von Willebrand factor. *J. Biol. Chem.* **278**: 29633–29639.
102. Dudek AZ, Nesmelova I, Mayo K, Verfaillie CM, Pitchford S, Slungaard A. 2003. Platelet factor 4 promotes adhesion of hematopoietic progenitor cells and binds IL-8: novel mechanisms for modulation of hematopoiesis. *Blood* **101**: 4687–4694.
103. Düringer C, Hamiche A, Gustafsson L, Kimura H, Svanborg C. 2003. HAMLET interacts with histones and chromatin in tumor cell nuclei. *J. Biol. Chem.* **278**: 42131–42185.
104. Dutkiewicz R, Schilke B, Knieszner H, Walter W, Craig EA, Marszalek J. 2003. Ssq1, a mitochondrial Hsp70 involved in iron-sulfur (Fe/S) center biogenesis. *J. Biol. Chem.* **278**: 29719–29727.
105. Elsen S, Duché O, Colbeau A. 2003. Interaction between the H2 sensor HupUV and the histidine kinase HupT controls HupSL hydrogenase synthesis in *Rhodobacter capsulatus*. *J. Bacteriol.* **185**: 7111–7119.
106. Evans L, Clarkson J, Yudkin MD, Errington J, Feucht A. 2003. Analysis of the interaction between the transcription factor σ^G and the anti-sigma factor SpoIIAB of *Bacillus subtilis*. *J. Bacteriol.* **185**: 4615–4619.
107. Facchiano A, Russo K, Facchiano AM, De Marchis F, Facchiano F, Ribatti D, Aguzzi MS, Capogrossi MC. 2003. Identification of a novel domain of fibroblast growth factor 2 controlling its angiogenic properties. *J. Biol. Chem.* **278**: 8751–8760.
108. Facchin S, Lopreiato R, Ruzzene M, Marin O, Sartori G, Götz C, Montenarh M, Carignani G, Pinna LA. 2003. Functional homology between yeast piD261/Bud32 and human PRPK: both phosphorylate p53 and PRPK partially complements piD261/Bud32 deficiency. *FEBS Lett.* **549**: 63–66.
109. Finnie C, Østergaard O, Sass Bak-Jensen K, Nielsen PK, Bønsager BC, Mori H, Nøhr J, Kramhøft B, Juge N, Svensson B. 2003. Barley proteome analysis, starch degrading enzymes and proteinaceous inhibitors. *J. Appl. Glycosci.* **50**: 277–282.
110. Flavigny J, Robert P, Camelin J-C, Schwartz K, Carrier L, Berrebi-Bertrand I. 2003. Biomolecular interactions between human recombinant β-MyHC and cMyBP-C simplicated in familial hypertrophic cardiomyopathy. *Cardiol. Res.* **60**: 388–396.
111. Foser S, Weyer K, Huber W, Certa U. 2003. Improved biological and transcriptional activity of monopegylated interferon-α-2a isomers. *Pharmacogen. J.* **3**: 312–319.
112. Fries M, Chauhan HJ, Domingo GJ, Jung H-I, Perham RN. 2003. Site-directed mutagenesis of a loop at the active site of E1 ($\alpha_2\beta_2$) of the pyruvate dehydrogenase complex. *Eur. J. Biochem.* **270**: 861–870.
113. Fries M, Jung H-I, Perham RN. 2003. Reaction mechanism of the heterotetrameric ($\alpha_2\beta_2$) E1 component of 2-oxo acid dehydrogenase multienzyme complexes. *Biochemistry* **42**: 6996–7002.
114. Fukushima K, Ikehara Y, Kanai M, Kochibe N, Kuroki M, Yamashita K. 2003. A β-*N*-acetylglucosanminyl phosphate diester residue is attached to the glycosylphosphatidylinositol anchor of human placental alkaline phosphatase. *J. Biol. Chem.* **278**: 36296–36303.
115. Fux L, Nussbaum-Shochat A, Amster-Choder O. 2003. Interactions between the PTS-regulation domains of the BglG transcriptional antiterminator from *Escherichia coli*. *J. Biol. Chem.* **278**: 46203–46209.
116. Gao Y, Kawano K, Yoshiyama S, Kawamichi H, Wang X, Nakamura A, Kohama K. 2003. Myosin light chain kinase stimulates smooth muscle myosin ATPase activity by binding to the myosin heads without phosporylating the myosin light chain. *Biochem. Biophys. Res. Commun.* **305**: 16–21.
117. Gibson N, McAlister-Henn L. 2003. Physical and genetic interactions of cytosolic malate dehydrogenase with other gluconeogenic enzymes. *J. Biol. Chem.* **278**: 25628–25636.
118. Graciet E, Gans P, Wedel N, Lebreton S, Camadro J-M, Gontero B. 2003. The small protein CP12: a protein linker for supramolecular complex assembly. *Biochemistry* **42**: 8163–8170.
119. Gregory LA, Thielens NM, Arlaud GJ, Fontecilla-Camps JC, Gaboriaud C. 2003. X-ray structure of the Ca^{2+}-binding interaction domain of C1s. *J. Biol. Chem.* **278**: 32157–32164.
120. Grönlund H, Bergman T, Sandström K, Alvelius G, Reininger R, Verdino P, Hauswirth A, Liderot K, Valent P, Spitzauer S, Keller W, Valenta R, van Hage-Hamsten M. 2003. Formation of disulfide bonds and homodimers of the major cat allergen Fel d 1 equivalent to the natural allergen by expression in *Escherichia coli*. *J. Biol. Chem.* **278**: 40144–40151.
121. Gross JD, Moerke NJ, von der Haar T, Lugovskoy AA, Sachs AB, McCarthy JEG, Wagner G. 2003. Ribosome loading onto the mRNA cap is driven by conformational coupling between eIF4G and eIF4E. *Cell* **115**: 739–750.
122. Hahn M-Y, Bae J-B, Park J-H, Roe J-H. 2003. Isolation and characterization of *Streptomyces coelicolor* RNA polymerase, its sigma, and antisigma factors. *Meth. Enzymol.* **370**: 73–83.
123. Hanna SM, Kirk P, Holt OJ, Puklavec MJ, Brown MH, Barclay AN. 2003. A novel form of the membrane protein CD147 that contains an extra Ig-like domain and interacts homophilically. *BMC Biochem.* **4**: 17.
124. He H, von der Haar T, Singh CR, Ii M, Li B, Hinnebusch AG, McCarthy JEG, Asano K. 2003. The yeast eukaryotic initiation factor 4G (eIF4G) heat domain interacts with eIF1 and eIF5 and is involved in stringent AUG selection. *Mol. Cell. Biol.* **23**: 5431–5445.
125. Hegasy GA, Wilhoeft U, Majno SA, Seeberger H, Zipfel PF, Hellwage J. 2003. Pig complement regulator factor H: molecular cloning and functional characterization. *Immunogenetics* **55**: 462–471.
126. Hill DM, Kasliwal T, Schwarz E, Hebert AM, Chen T, Gubina E, Zhang L, Kozlowski S. 2003. A dominant negative mutant β2-microglobulin blocks the extracellular folding of a major histocompatibility complex class I heavy chain. *J. Biol. Chem.* **278**: 5630–5638.
127. Himmel M, van der Ven PFM, Stöcklein W, Fürst DO. 2003. The limits of promiscuity: isoform-specific dimerization of filamins. *Biochemistry* **42**: 430–439.
128. Hinds MG, Lackmann M, Skea GL, Harrison PJ, Huang DCS, Day CL. 2003. The structure of Bcl-w reveals a role for the C-terminal residues in modulating biological activity. *EMBO J.* **22**: 1497–1507.
129. Hirota M, Kuwata K, Ohmuraya M, Ogawa M. 2003. Significance of trypsin inhibitor gene mutation in the predisposition to pancreatitis. *Int. Congress Ser.* **1255**: 41–48.
130. Ho MS, Carniol K, Losick R. 2003. Evidence in support of a docking model for the release of the transcription factor σ^F from the antisigma factor SpoIIAB in *Bacillus subtilis*. *J. Biol. Chem.* **278**: 20898–20905.
131. Hoff KG, Cupp-Vickery JR, Vickery LE. 2003. Contributions of the LPPVK motif of the iron-sulfur template protein IscU to interactions with the Hsc66-Hsc20 chaperone system. *J. Biol. Chem.* **278**: 37582–37589.
132. Holmfeldt P, Brännström K, Stenmark S, Gullberg M. 2003. Deciphering the cellular functions of the Op18/stathmin family

of microtubule-regulators by plasma membrane-targeted localization. *Mol. Biol. Cell* **14**: 3716–3729.
133. Hornemann T, Kempa S, Himmel M, Hayeß K, Fürst DO, Wallimann T. 2003. Muscle-type creatine kinase interacts with central domains of the M-brand proteins myomesin and M-protein. *J. Mol. Biol.* **332**: 877–887.
134. Huang Y, Rich RL, Myszka DG, Wu H. 2003. Requirement of both the second and third BIR domains for the relief of X-linked inhibitor of apoptosis protein (XIAP)-mediated caspase inhibition by Smac. *J. Biol. Chem.* **278**: 49517–49522.
135. Hutchinson SL, Wooldridge L, Tafuro S, Laugel B, Glick M, Boulter JM, Jakobsen BK, Price DA, Sewell AK. 2003. The CD8 T cell coreceptor exhibits disproportionate biological activity at extremely low binding affinities. *J. Biol. Chem.* **278**: 24285–24293.
136. Hyland EM, Rezende LF, Richardson CC. 2003. The DNA binding domain of the gene 2.5 single-stranded DNA-binding protein of bacteriophage T7. *J. Biol. Chem.* **278**: 7247–7256.
137. Ikeda W, Kakunaga S, Itoh S, Shingai T, Takekuni K, Satoh K, Inoue Y, Hamaguchi A, Morimoto K, Takeuchi M, Imai T, Takai Y. 2003. Tage4/nectin-like molecule-5 heterophilically *trans*-interacts with cell adhesion molecule nectin-3 and enhances cell migration. *J. Biol. Chem.* **278**: 28167–28172.
138. Ilbert M, Méjean V, Giudici-Orticoni M-T, Samama J-P, Iobbi-Nivol C. 2003. Involvement of a mate chaperone (TorD) in the maturation pathway of molybdoenzyme TorA. *J. Biol. Chem.* **278**: 28787–28792.
139. Iwananga S, Okada M, Isawa H, Morita A, Yuda M, Chinzei Y. 2003. Identification and characterization of novel salivary thrombin inhibitors from the ixodidae tick, *Haemaphysalis longicornis*. *Eur. J. Biochem.* **270**: 1926–1934.
140. Jacob R, Heine M, Alfalah M, Naim HY. 2003. Distinct cytoskeletal tracks direct individual vesicle populations to the apical membrane of epithelial cells. *Curr. Biol.* **13**: 607–612.
141. Jiang J, Taylor AB, Prasad K, Ishikawa-Brush Y, Hart PJ, Lafer EM, Sousa R. 2003. Structure-function analysis of the auxilin J-domain reveals an extended Hsc70 interaction interface. *Biochemistry* **42**: 5748–5753.
142. Jung H-I, Cooper A, Perham RN. 2003. Interactions of the peripheral subunit-binding domain of the dihydrolipoyl acetyltransferase component in the assembly of the pyruvate dehydrogenase multienzyme complex of *Bacillus stearothermophilus*. *Eur. J. Biochem.* **270**: 4488–4496.
143. Jung H-I, Perham RN. 2003. Prediction of the binding site on E1 in the assembly of the pyruvate dehydrogenase multienzyme complex of *Bacillus stearothermophilus*. *FEBS Lett.* **555**: 405–410.
144. Kantham L, Kerr-Bayles L, Godde N, Quick M, Webb R, Sunderland T, Bond J, Walder K, Augert G, Collier G. 2003. Beacon interacts with cdc2/cdc28-like kinases. *Biochem. Biophys. Res. Commun.* **304**: 125–129.
145. Khoshnoodi J, Sigmundsson, Öfverstedt L-G, Skoglund U, Öbrink B, Wartiovaara J, Tryggvason K. 2003. Nephrin promotes cell-cell adhesion through homophilic interactions. *Am. J. Path.* **163**: 2337–2346.
146. Kim S, Ko J, Shin H, Lee J-R, Lim C, Han J-H, Altrock WD, Garner CC, Gundelfinger ED, Premont RT, Kaang B-K, Kim E. 2003. The GIT family of proteins forms multimers and associates with the presynaptic cytomatrix protein piccolo. *J. Biol. Chem.* **278**: 6291–6300.
147. Kindermann M, George N, Johnsson N, Johnsson K. 2003. Covalent and selective immobilization of fusion proteins. *J. Am. Chem. Soc.* **125**: 7810–7811.
148. Kontrogianni-Konstantopoulos A, Jones EM, van Rossum DB, Bloch RJ. 2003. Obscurin is a ligand for small ankyrin 1 in skeletal muscle. *Mol. Biol. Cell* **14**: 1138–1148.
149. Kovács J, Löw P, Pácz A, Horváth I, Oláh J, Ovádi J. 2003. Phosphoenolpyruvate-dependent tubulin-pyruvate kinase interaction at different organizational levels. *J. Biol. Chem.* **278**: 7126–7130.
150. Kurihara T, Mihara H, Kato S-i, Yoshimura T, Esaki N. 2003. Assembly of iron-sulfur clusters mediated by cysteine desulfurases, IscS, CsdB and CSD, from *Escherichia coli*. *Biochim. Biophys. Acta* **1647**: 303–309.
151. Kusu N, Laurikkala J, Imanishi M, Usui H, Konishi M, Miyake A, Thesleff I, Itoh N. 2003. Sclerostin is a novel secreted osteoclast-derived bone morphogenetic protein antagonist with unique ligand specificity. *J. Biol. Chem.* **278**: 24113–24117.
152. Laurikkala J, Kassai Y, Pakkasjärvi L, Thesleff I, Itoh N. 2003. Identification of a secreted BMP antagonist, ectodin, integrating BMP, FGF, and SHH signals from the tooth enamel knot. *Dev. Biol.* **264**: 91–105.
153. Lebreton S, Graciet E, Gontero B. 2003. Modulation, via protein-protein interactions, of glyceraldehyde-3-phosphate dehydrogenase activity through redox phosphoribulokinase regulation. *J. Biol. Chem.* **278**: 12078–12084.
154. Lee K, Zhan X, Gao J, Feng Y, Meganathan R, Cohen SN, Georgiou G. 2003. RraA: a protein inhibitor of RNase E activity that globally modulates RNA abundance in *E. coli*. *Cell* **114**: 623–634.
155. Lehtolainen P, Wirth T, Taskinen AK, Lehenkari P, Leppänen O, Lappalainen M, Pulkkanen K, Marttila A, Marjomäki V, Airenne KJ, Horton M, Kulomaa MS, Ylä-Herttuala S. 2003. Targeting of biotinylated compounds to its target tissue using a low-density lipoprotein receptor-avidin fusion protein. *Gene Ther.* **10**: 2090–2097.
156. Leng L, Metz CN, Fang Y, Xu J, Donnelly S, Baugh J, Delohery T, Chen Y, Mitchell RA, Bucala R. 2003. MIF signal transduction initiated by binding to CD74. *J. Exp. Med.* **197**: 1467–1476.
157. Lesuisse E, Santos R, Matzanke BF, Knight SAB, Camadro J-M, Dancis A. 2003. Iron use for haeme synthesis is under control of the yeast frataxin homologue (Yfh1). *Hum. Mol. Genet.* **12**: 879–889.
158. Linhult M, Gülich S, Gräslund T, Nygren P-Å, Hober S. 2003. Evaluation of different linker regions for multimerization and coupling chemistry for immobilization of a proteinaceous affinity ligand. *Prot. Engng.* **16**: 1147–1152.
159. Lipman RSA, Chen J, Evilia C, Vitseva O, Hou Y-M. 2003. Association of an aminoacyl-tRNA synthetase with a putative metabolic protein in archaea. *Biochemistry* **42**: 7487–7496.
160. Llorens F, Roher N, Miró FA, Sarno S, Ruiz FX, Meggio F, Planna M, Pinna LA, Itarte E. 2003. Eukaryotic translation-initiation factor eIF2β binds to protein kinase CK2: effects on CK2β activity. *Biochem. J.* **375**: 623–631.
161. Lopian L, Nussbaum-Shochat A, O'Day-Kerstein K, Wright A, Amster-Choder O. 2003. The BglF sensor recruits the BglG transcription regulator to the membrane and releases it on stimulation. *Proc. Natl. Acad. Sci. USA* **100**: 7099–7104.
162. Lu ZH, Dameron CT, Solioz M. 2003. The *Enterococcus hirae* paradigm of copper homeostasis: copper chaperone turnover, interactions, and transactions. *Biometals* **16**: 137–143.
163. Lyakhovich A, Shekhar MPV. 2003. Supramolecular complex formation between Rad6 and proteins of the p53 pathway during DNA damage-induced response. *Mol. Cell. Biol.* **23**: 2463–2475.
164. Mantovani A, Garlanda C, Bottazzi B. 2003. Pentraxin 3, a non-redundant soluble pattern recognition receptor involved in innate immunity. *Vaccine* **21**: S2/43–S2/47.
165. Manuellan T, Hellwage J, Meri S, Caprioli J, Noris M, Heinen S, Jozsi M, Neumann HPH, Remuzzi G, Zipfel PF. 2003. Mutations in factor H reduce binding affinity to C3b and heparin and surface attachment to endothelial cells in hemolytic uremic syndrome. *J. Clin. Invest.* **111**: 1181–1190.
166. McRobert EA, Gallicchio M, Jerums G, Cooper ME, Bach LA. 2003. The amino-terminal domains of the ezrin, radixin, and moesin (ERM) proteins bind advanced glycation end products, an interaction that may play a role in the development of diabetic complications. *J. Biol. Chem.* **278**: 25783–25789.
167. Merithew E, Stone C, Eathiraj S, Lambright DG. 2003. Determinants of Rab5 interactions with the N terminus of early endosome antigen 1. *J. Biol. Chem.* **278**: 8494–8500.
168. Modesti M, Junop MS, Ghirlando R, van de Rakt M, Gellert M, Yang W, Kanaar R. 2003. Tetramerization and DNA ligase IV interaction of the DNA double-strand break repair protein XRCC4 are mutually exclusive. *J. Mol. Biol.* **334**: 215–228.
169. Morgan JR, Prasad K, Jin S, Augustine GJ, Lafer EM. 2003. Eps15 homology domain-NPF motif interactions regulate clathrin coat assembly during synaptic vesicle recycling. *J. Biol. Chem.* **278**: 33583–33592.

170. Nakano H, Yoshida T, Uchiyama S, Kawachi M, Matsuo H, Kato T, Ohshima A, Yamaichi Y, Honda T, Kato H, Yamagata Y, Ohkubo T, Kobayashi Y. 2003. Structure and binding mode of a ribosome recycling factor (RRF) from mesophilic bacterium. *J. Biol. Chem.* **278**: 3427–3436.
171. Nanao M, Ricard-Blum S, Di Guilmi AM, Lemaire D, Lascoux D, Chabert J, Attree I, Dessen A. 2003. Type III secretion proteins PcrV and PcrG from *Pseudomonas aeruginosa* form a 1:1 complex through high affinity interactions. *BMC Microbiol.* **3**: 21.
172. Nedialkov YA, Shooltz DD, Trlezenberg SJ. 2003. Purification and protein interaction assays of the VP16C trranscription activation domain. *Meth. Enzymol.* **370**: 522–535.
173. Nielsen PK, Bønsager BC, Berland CR, Sigurskjold BW, Svensson B. 2003. Kinetics and energetics of the binding between barley α-amylase/subtilisin inhibitor and barley α-amylase 2 analyzed by surface plasmon resonance and isothermal titration calorimetry. *Biochemistry* **42**: 1478–1487.
174. Nomura M, Shimizu S, Sugiyama T, Narita M, Ito T, Matsuda H, Tsujimoto Y. 2003. 14-3-3 interacts directly with and negatively regulates pro-apoptotic Bax. *J. Biol. Chem.* **278**: 2058–2065.
175. Odunuga OO, Hornby JA, Bies C, Zimmermann R, Pugh DJ, Blatch GL. 2003. Tetratricopeptide repeat motif-mediated Hsc70-mSTI1 interaction. *J. Biol. Chem.* **278**: 6896–6904.
176. Ong L-L, Er CPN, Ho A, Aung MT, Yu H. 2003. Kinectin anchors the translation elongation factor-1δ to the endoplasmic reticulum. *J. Biol. Chem.* **278**: 32115–32123.
177. Pandiripally V, Wei L, Skerka C, Zipfel PF, Cue D. 2003. Recruitment of complement factor H-like protein 1 promotes intracellular invasion by group A streptococci. *Infect. Immun.* **71**: 7119–7128.
178. Philipp J, Dienst A, Unruh M, Wagener A, Grunow A, Engert A, Fries JW, Gottstein C. 2003. Soluble tissue factor induces coagulation on tumor endothelial cells in vivo if coadministered with low-dose lipopolysaccharides. *Arterioscler. Thromb. Vasc. Biol.* **23**: 905–910.
179. Raasi S, Pickart CM. 2003. Rad23 ubiquitin-associated domains (UBA) inhibit 26 S proteasome-catalyzed proteolysis by sequestering lysine 48-linked polyubiquitin chains. *J. Biol. Chem.* **278**: 8951–8959.
180. Rabel C, Grahn AM, Lurz R, Lanka E. 2003. The VirB4 family of proposed traffic nucleosied triphosphatases: common motifs in plasmid RP4 TrbE are essential for conjugation and phage adsorption. J. Bacteriol. **185**: 1045–1058.
181. Rakus D, Mamczur P, Gizak A, Dus D, Dzugaj A. 2003. Colocalization of muscle FBPase and muscle aldolase on both sides of the Z-line. *Biochem. Biophys. Res. Commun.* **311**: 294–299.
182. Rakus D, Pasek M, Krothklewski H, Dzugaj A. 2003. Muscle FBPase in a complex with muscle aldolase is insensitive to AMP inhibition. *FEBS Lett.* **547**: 11–14.
183. Ramström H, Sanglier S, Leize-Wagner E, Philippe C, Van Dorsselaer A, Haiech J. 2003. Properties and regulation of the bifunctional enzyme HPr kinase/phosphatase in *Bacillus subtilis*. *J. Biol. Chem.* **278**: 1174–1185.
184. Rezende LF, Willcox S, Griffith JD, Richardson CC. 2003. A single-stranded DNA-binding protein of bacteriophage T7 defective in DNA annealing. *J. Biol. Chem.* **278**: 29098–29105.
185. Rhee J, Takahashi Yu, Saga Y, Wilson-Rawls J, Rawls A. 2003. The protocadherin papc is involved in the organization of the epithelium along the segmental border during mouse somitogenesis. *Dev. Biol.* **254**: 248–261.
186. Richter K, Muschler P, Hainzl O, Reinstein J, Buchner J. 2003. Sti1 is a non-competitive inhibitor of the Hsp90 ATPase. *J. Biol. Chem.* **278**: 10328–10333.
187. Rishal I, Keren-Raifman T, Yakubovich D, Ivanina T, Dessauer CW, Slepak VZ, Dascal N. 2003. Na^+ promotes the dissociation between $G\alpha_{GDP}$ and $G\beta\gamma$, activating G protein-gated K^+ channels. *J. Biol. Chem.* **278**: 3840–3845.
188. Rohlena J, Kolkman JA, Boertjes RC, Mertens K, Lenting PJ. 2003. Residues Phe^{342}-Asn^{348} of activated coagulation factor IX contribute to the interaction with low density lipoprotein receptor-related protein. *J. Biol. Chem.* **278**: 9394–9401.
189. Rollenhagen C, Antelmann H, Kirstein J, Delumeau O, Hecker M, Yudkin MD. 2003. Binding of σ^A and σ^B to core RNA polymerase after environmental stress in *Bacillus subtilis*. *J. Bacteriol.* **185**: 35–40.
190. Root MJ, Hamer DH. 2003. Targeting therapeutics to an exposed and conserved binding element of the HIV-1 fusion protein. *Proc. Natl. Acad. Sci. USA* **100**: 5016–5021.
191. Rougé P, Peumans WJ, Barre A, Van Damme EJM. 2003. A structural basis for the difference in specificity between the two jacalin-related lectins from mulberry (*Morus nigra*) bark. *Biochem. Biophys. Res. Commun.* **304**: 91–97.
192. Sakurai Y, Shima M, Matsumoto T, Takatsuka H, Nishiya K, Kasuda S, Fujimura Y, Yoshioka A. 2003. Anticoagulant activity of M-LAO, L-amino acid oxidase purified from *Agkistrodon halys blomhoffii*, through selective inhibition of factor IX. *Biochim. Biophys. Acta* **1649**: 51–57.
193. Sancho AI, Faulds CB, Svensson B, Bartolomé B, Williamson G, Juge N. 2003. Cross-inhibitory activity of cereal protein inhibitors against α-amylases and xylanases. *Biochim. Biophys. Acta* **1650**: 136–144.
194. Sandström K, Xu Z, Forsberg G, Nygren P-Å. 2003. Inhibition of the CD28-CD80 co-stimulation signal by a CD28-binding affibody ligand developed by combinatorial protein engineering. *Prot. Engng.* **16**: 691–697.
195. Schröder G, Lanka E. 2003. TraG-like proteins of type IV secretion systems: functional dissection of the multiple activities of TraG (RP4) and TrwB (R388). *J. Bacteriol.* **185**: 4371–4381.
196. Seet BT, McCaughan CA, Handel TM, Mercer A, Brunetti C, McFadden G, Fleming SB. 2003. Analysis of an orf virus chemokine-binding protein: shifting ligand specificities among a family of poxvirus viroceptors. *Proc. Natl. Acad. Sci. USA* **100**: 15137–15142.
197. Shand JH, Beattie J, Song H, Phillips K, Kelly SM, Flint DJ, Allan GJ. 2003. Specific amino acid substitutions determine the differential contribution of the N- and C-terminal domains of insulin-like growth factor (IGF)-binding protein-5 in binding IGF-I. *J. Biol. Chem.* **278**: 17859–17866.
198. Shiba T, Kawasaki M, Takatsu H, Nogi T, Matsugaki N, Igarashi N, Suzuki M, Kato R, Nakayama K, Wakatsuki S. 2003. Molecular mechanism of membrane recruitment of GGA by ARF in lysosomal protein transport. *Nat. Struct. Biol.* **10**: 386–393.
199. Singha NC, Vlamis-Gardikas A, Holmgren A. 2003. Real-time kinetics of the interaction between the two subunits, *Escherichia coli* thioredoxin and gene 5 protein of phage T7 DNA polymerase. *J. Biol. Chem.* **278**: 21421–21428.
200. Slater SJ, Cook AC, Selz JL, Malinowski SA, Stagliano BA, Stubbs CD. 2003. Effects of ethanol on protein kinase C α activity induced by association with Rho GTPases. *Biochemistry* **42**: 12105–12114.
201. Snyder JT, Singer AU, Wing MR, Harden TK, Sondek J. 2003. The pleckstrin homology domain of phospholipase C-β_2 as an effector site for Rac. *J. Biol. Chem.* **278**: 21099–21104.
202. Soelaiman S, Wei BQ, Bergson P, Lee Y-S, Shen Y, Mrksich M, Shoichet BK, Tang W-J. 2003. Structurebased inhibitor discovery against adenylyl cyclase toxins from pathogenic bacteria that cause anthrax and whooping cough. *J. Biol. Chem.* **278**: 25990–25997.
203. Spiller OB, Blackbourn DJ, Mark L, Proctor DG, Blom AM. 2003. Functional activity of the complement regulator encoded by Kaposi's sarcoma associated herpesvirus. *J. Biol. Chem.* **278**: 9283 -9289.
204. Šribar J, Sherman NE, Prijatelj P, Faure G, Gubenšek F, Fox JW, Aitken A, Pungerčar J, Krlaj I. 2003. The neurotoxic phospholipase A2 associates, through a nonphosphorylated binding motif, with 14-3-3 protein γ and ε isoforms. *Biochem. Biophys. Res. Commun.* **302**: 691–696.
205. Strausak D, Howie MK, Firth SD, Schlicksupp A, Pipkorn R, Multhaup G, Mercer JFB. 2003. Kinetic analysis of the interaction of the copper chaperone Atox1 with the metal binding sites of the Menkes protein. *J. Biol. Chem.* **278**: 20821–20827.
206. Stute J, Pourmotabbed T, Tschesche H. 2003. Kinetic analysis of the binding of hemopexin-like domain of gelatinase B cloned and expressed in Pichia pastoris to tissue inhibitor of metalloproteinases-1. *J. Prot. Chem.* **22**: 509–514.

207. Sun Z, Scott DJ, Lund PA. 2003. Isolation and characterisation of mutants of GroEL that are fully functional as single rings. *J. Mol. Biol.* 332: 715–728.
208. Svitel J, Balbo A, Mariuzza RA, Gonzales NR, Schuck P. 2003. Combined affinity and rate constant distributions of ligand populations from experimental surface binding kinetics and equilibria. *Biophys. J.* 84: 4062–4077.
209. Takeuchi K, Yokogawa M, Matsuda T, Sugai M, Kawano S, Kohno T, Nakamura H, Takahashi H, Shimada I. 2003. Structural basis of the KcsA K^+ channel and agitoxin2 pore-blocking toxin interaction by using the transferred cross-saturation method. *Structure* 11: 1381–1392.
210. Tan Y-J, Teng E, Ting AE. 2003. A small inhibitor of the interaction between Bax and Bcl-X_L can synergize with methylprednisolone to induce apoptosis in Bcl-X_L-overexpressing breast-cancer cells. *J. Cancer Res. Clin. Oncol.* 129: 437–448.
211. Taoka M, Ichimura T, Wakamiya-Tsuruta A, Kubota Y, Araki T, Obinata T, Isobe T. 2003. V-1, a protein expressed transiently during murine cerebellar development, regulates actin polymerization via interaction with capping protein. *J. Biol. Chem.* 278: 5864–5870.
212. Thai C-T, Ogata RT. 2003. Expression and characterization of the C345C/NTR domains of complement components C3 and C5. *J. Immunol.* 171: 6565–6573.
213. Timmins J, Schoehn G, Ricard-Blum S, Scianimanico S, Vernet T, Ruigrok RWH, Weissenhorn W. 2003. Ebola virus matrix protein VP40 interaction with human cellular factors Tsg101 and Nedd4. *J. Mol. Biol.* 326: 493–502.
214. Tirián L, Hlavanda E, Oláh J, Horváth I, Orosz F, Szabó B, Kovács J, Szabad J, Ovádi J. 2003. TPPP/p25 promotes tubulin assemblies and blocks mitotic spindle formation. *Proc. Natl. Acad. Sci. USA* 100: 13976–13981.
215. Todorova RT, Saihara Y. 2003. Specific binding of ribosome recycling factor (RRF) with the Escherichia coli ribosomes by BIACORE. *Mol. Biol. Rep.* 30: 113–119.
216. Ulrich HD. 2003. Protein-protein interactions within an E2-RING finger complex. *J. Biol. Chem.* 278: 7051–7058.
217. Van Eynde A, Bollen M. 2003. Validation of interactions with protein phosphatase-1. *Meth. Enzymol.* 366: 144–156.
218. Van Hemert MJ, Deelder AM, Molenaar C, Steensma HY, Van Heusden GPH. 2003. Self-association of the spindle pole body-related intermediate filament protein Fin1p and its phosphorylation-dependent interaction with 14-3-3 proteins in yeast. *J. Biol. Chem.* 278: 15049–15055.
219. Volpers C, Thirion C, Biermann V, Hussmann S, Kewes H, Dunant P, von der Mark H, Herrmann A, Kochanek S, Lochmüller H. 2003. Antibody-mediated targeting of an adenovirus vector modified to contain a synthetic immunoglobulin G-binding domain in the capsid. *J. Virol.* 77: 2093–2104.
220. Vostiar I, Tkac J, Mandenius C-F. 2003. Monitoring of the heat-shock response in *Escherichia coli* using an optical biosensor. *Anal. Biochem.* 322: 156–163.
221. Wakasugi K, Nakano T, Morishima I. 2003. Oxidized human neuroglobin acts as a heterotrimeric $G\alpha$ protein guanine nucleotide dissociation inhibitor. *J. Biol. Chem.* 278: 36505–36512.
222. Wakeham DE, Chen C-Y, Greene B, Hwang PK, Brodsky FM. 2003. Clathrin self-assembly involves coordinated weak interactions favorable for cellular regulation. *EMBO J.* 22: 4980–4990.
223. Wang B, Alam SL, Meyer HH, Payne M, Stemmler TL, Davis DR, Sundquist WI. 2003. Structure and ubiquitin interactions of the conserved zinc finger domain of Np14. *J. Biol. Chem.* 278: 20225–20234.
224. Wang W, Cole AM, Hong T, Waring AJ, Lehrer RI. 2003. Retrocyclin, an antiretroviral θ-defensin, is a lectin. *J. Immunol.* 170: 4708–4716.
225. Wegele H, Haslbeck M, Reinstein J, Buchner J. 2003. Sti1 is a novel activator of the Ssa proteins. *J. Biol. Chem.* 278: 25970–25976.
226. Wilkinson FL, Holaska JM, Zhang Z, Sharma A, Manilal S, Holt I, Stamm S, Wilson KL, Morris GE. 2003. Emerin interacts *in vitro* with the splicing-associated factor, YT521-B. *Eur. J. Biochem.* 270: 2459–2466.
227. Winkler DG, Sutherland MK, Georghegan JC, Yu C, Hayes T, Skonier JE, Shpektor D, Jonas M, Kovacevich BR, Staehling-Hampton K, Appleby M, Brunkow ME, Latham JA. 2003. Osteocyte control of bone formation via sclerostin, a novel BMP antagonist. *EMBO J.* 22: 6267–6276.
228. Witte G, Urbanke C, Curth U. 2003. DNA polymerase III χ subunit ties single-stranded DNA binding protein to the bacterial replication machinery. *Nucl. Acids Res.* 31: 4434–4440.
229. Xu G, Rich RL, Steegborn C, Min T, Huang Y, Myszka DG, Wu H. 2003. Mutational analyses of the p35-caspase interaction. *J. Biol. Chem.* 278: 5455–5461.
230. Yamaguchi S, Mannen T, Zako T, Kamiya N, Nagamune T. 2003. Measuring adsorption of a hydrophobic probe with a surface plasmon resonance sensor to monitor conformational changes in immobilized proteins. *Biotechnol. Prog.* 19: 1348–1354.
231. Yaqub S, Abrahamsen H, Zimmerman B, Kholod N, Torgersen KM, Mustelin T, Herberg FW, Taskén K, Vang T. 2003. Activation of C-terminal Src kinase (Csk) by phosphorylation at Ser-364 depends on the Csk SH3 domain. *Biochem. J.* 372: 271–278.
232. Yasumi M, Shimizu K, Honda T, Takeuchi M, Takai Y. 2003. Role of each immunoglobulin-like loop of nectin for its cell-cell adhesion activity. *Biochem. Biophys. Res. Commun.* 302: 61–66.
233. Zhai P, Wakeham N, Loy JA, Zhang XC. 2003. Functional roles of streptokinase C-terminal flexible peptide in active site formation and substrate recognition in plasminogen activation. *Biochemistry* 42: 114–120.
234. Zhang X, Oglesbee M. 2003. Use of surface plasmon resonance for the measurement of low affinity binding interactions between HSP72 and measles virus nucleocapsid protein. *Biol. Proced. Online* 5: 170–181.
235. Zhang Y-M, Wu B, Zheng J, Rock CO. 2003. Key residues responsible for acyl carrier protein and β-ketoacyl-acyl carrier protein reductase (FabG) interaction. *J. Biol. Chem.* 278: 52935–52943.

Antibodies.

236. Afanasieva TA, Wittmer M, Vitaliti A, Ajmo M, Neri D, Klemenz R. 2003. Single-chain antibody and its derivatives directed against vascular endothelial growth factor: application for antiangiogenic gene therapy. *Gene Therapy* 10: 1850–1859.
237. Ahamed A, Rahman A, Hayashi F, Ueji S, Amakawa T, Tsurumi S. 2003. Isolation of chromosaponin I-specific antibody by affinity chromatography. *Biochem. Biophys. Res. Commun.* 302: 587–592.
238. Amin K, Ekberg-Jansson A, Löfdahl C-G, Venge P. 2003. Relationship between inflammatory cells and structural changes in the lungs of asymptomatic and never smokers: a biopsy study. *Thorax* 58: 135–142.
239. Artsaenko O, Tessmann K, Sack M, Häussinger D, Heintges T. 2003. Abrogation of hepatitis C virus N53 helicase enzymatic activity by recombinant human anitbodies. *J. Gen. Virol.* 84: 2323–2332.
240. Ásgeirsdóttir SA, Kok RJ, Everts M, Meijer DKF, Molema G. 2003. Delivery of pharmacologically active dexamethasone into activated endothelial cells by dexamethasone-anti-E-selection immunoconjugate. *Biochem. Pharmac.* 65: 1729–1739.
241. Azria D, Dorvillius M, Gourgou S, Martineau P, Robert B, Pugnière M, Delard R, Ychou M, Dubois J-B, Pèlegrin A. 2003. Enhancement of radiation therapy by tumor necrosis factor alpha in human colon cancer using a bispecific antibody. *Intl. J. Radiat. Oncol. Biol. Phys.* 55: 1363–1373.
242. Bai J, Sui J, Zhu RY, St. Clair Tallarico A, Gennari F, Zhang D, Marasco WA. 2003. Inhibition of Tat-mediated transactivation and HIV-1 replication by human antihcyclinT1 intrabodies. *J. Biol. Chem.* 278: 1433–1442.
243. Basta M, Van Goor F, Luccioli S, Billings EM, Vortmeyer AO, Baranyi L, Szebeni J, Alving CR, Carroll MC, Berkower I, Stojilkovic SS, Metcalfe DD. 2003. F(ab)'$_2$-mediated neutralization of C3a and C5a anaphylatoxins: a novel effector function of immunoglobulins. *Nat. Med.* 9: 431–438.

244. Bès C, Briant-Longuet L, Cerutti M, Heitz F, Troadec S, Pugnière M, Roquet F, Molina F, Cassat F, Bresson D, Péraldi-Roux S, Devauchelle G, Devaux C, Granier C, Chardès T. 2003. Mapping the paratope of the anti-CD4 recombinant Fab 13B8.2 by combining parallel peptide synthesis and site-directed mutagenesis. *J. Biol. Chem.* 278: 14265–14273.
245. Bijnens AP, Gils A, Jutten B, Faber BC, Heeneman S, Kitslaar PJ, Tordoir JH, de Vries CJM, Kroon AA, Daemen MJAP, Cleutjens KBJM. 2003. Vasculin, a novel vascular protein differentially expressed in human atherogenesis. *Blood* 102: 2803–2810.
246. Bond CJ, Marsters Jr. JC, Sidhu SS. 2003. Contributions of CDR3 to V_HH domain stability and the design of monobody scaffolds for naive antibody libraries. *J. Mol. Biol.* 332: 643–655.
247. Borchmann P, Treml JF, Hansen H, Gottstein C, Schnell R, Staak O, Zhang H-f, Davis T, Keler T, Diehl V, Graziano RF, Engert A. 2003. The human anti-CD30 antibody 5F11 shows in vitro and in vivo activity against malignant lymphoma. *Blood* 102: 3737–3742.
248. Brennan J, Dillon P, O'Kennedy R. 2003. Production, purification and characterisation of genetically derived scFv and bifunctional antibody fragments capable of detecting illicit drug residues. *J. Chromatogr. B* 786: 327–342.
249. Bresson D, Cerutti M, Devauchelle G, Pugnière M, Roquet F, Bès C, Bossard C, Chardès T, Péraldi-Roux S. 2003. Localization of the discontinuous immunodominant region recognized by human anti-thyroperoxidase autoantibodies in autoimmune thyroid disease. *J. Biol. Chem.* 278: 9560–9569.
250. Burtrum D, Zhu Z, Lu D, Anderson DM, Prewett M, Pereira DS, Bassi R, Abdullah R, Hooper AT, Koo H, Jimenez X, Johnson D, Apblett R, Kussie P, Bohlen P, Witte L, Hicklin DJ, Ludwig DL. 2003. A fully human monoclonal antibody to the insulin-like growth factor I receptor blocks ligand-dependent signaling and inhibits human tumor growth *in vivo*. *Cancer Res.* 63: 8912–8921.
251. Carnahan J, Wang P, Kendall R, Chen C, Hu S, Boone T, Juan T, Talvenheimo J, Montestruque S, Sun J, Elliott G, Thomas J, Ferbas J, Kern B, Briddell R, Leonard JP, Cesano A. 2003. Epratuzumab, a humanized monoclonal antibody targeting CD22: characterization of *in vitro* properties. *Clin. Cancer Res.* 9: 3982s–3990s.
252. Cesaro-Tadic S, Lagos D, Honegger A, Rickard JH, Partridge LJ, Blackburn GM, Plückthun A. 2003. Turnover-based *in vitro* selection and evolution of biocatalysts from a fully synthetic antibody library. *Nat. Biotech.* 21: 679–685.
253. Chang Y-J, Wu H-L, Hsu Y-C, Hamaguchi N, Shi G-Y, Shen M-C, Lin S-W. 2003. Discontinuous residues of factor IX constitute a surface for binding the anti-factor IX monoclonal antibody A-5. *Thromb. Res.* 111: 293–299.
254. Chen B-H, Kilmon MA, Ma C, Caven TH, Chan-Li Y, Shelburne AE, Tombes RM, Roush E, Conrad DH. 2003. Temperature effect on IgE binding to CD23 versus FcεRI. *J. Immunol.* 170: 1839–1845.
255. Colman RW, Pixley RA, Sainz IM, Song JS, Isordia-Salas I, Muhamed SN, Powell JA, Mousa SA. 2003. Inhibition of angiogenesis by antibody blocking the action of proangiogenic high-molecular-weight kininogen. *J. Thromb. Haemost.* 1: 164–170.
256. Cordeiro MF. 2003. Technology evaluation: Lerdelimumab, Cambridge Antibody Technology. *Curr. Opin. Mol. Ther.* 5: 199–203.
257. Cui X, Pei R, Wang Z, Yang F, Ma Y, Dong S, Yang X. 2003. Layer-by-layer assembly of multilayer films composed of avidin and biotin-labeled antibody for immunosensing. *Biosens. Bioelectron.* 18: 59–67.
258. Cui X, Yang F, Sha Y, Yang X. 2003. Real-time immunoassay of ferritin using surface plasmon resonance biosensor. *Talanta* 60: 53–61.
259. Daumas F, Destainville N, Millot C, Lopez A, Dean D, Salome L. 2003. Confined diffusion without fences of a G-protein-coupled receptor as revealed by single particle tracking. *Biophys. J.* 84: 356–366.
260. De Pascalis R, Gonzales NR, Padlan EA, Schuck P, Batra SK, Schlom J, Kashmiri SVS. 2003. *In vitro* affinity maturation of a specificity-determined region-grafted humanized anticarcinoma antibody: isolation and characterization of minimally immunogenic high-affinity variants. *Clin. Cancer Res.* 9: 5521–5531.
261. De Santis R, Anastasi AM, D'Alessio V, Pelliccia A, Albertoni C, Rosi A, Leoni B, Lindstedt R, Petronzelli F, Dani M, Verdoliva A, Ippolito A, Campanile N, Manfredi V, Esposito A, Cassani G, Chinol M, Paganelli G, Carminati P. 2003. Novel antitenascin antibody with increased tumor localisation for Pretargeted Antibody-Guided RadioImmunoTherapy (PAGRIT^R). *Br. J. Cancer* 88: 996–1003.
262. Deckert PM, Renner C, Cohen LS, Jungbluth A, Ritter G, Bertino JR, Old LJ, Welt S. 2003. A33scFv-cytosine deaminase: a recombinant protein construct for antibody-directed enzyme-prodrug therapy. *Br. J. Cancer* 88: 937–939.
263. Deyev SM, Waibel R, Lebedenko EN, Schubiger AP, Plückthun A. 2003. Design of multivalent complexes using the barnase-barstar module. *Nat. Biotech.* 21: 1486–1492.
264. Dolezal O, De Gori R, Walter M, Doughty L, Hattarki M, Hudson PJ, Kortt AA. 2003. Single-chain Fv multimers of the anti-neuraminidase antibody NC10: the residue at position 15 in the V_L domain of the scFv-0 (V_L-V_H) molecule is primarily responsible for formation of a tetramer-trimer equlibrium. *Prot. Engng.* 16: 47–56.
265. Donini M, Morea V, Desiderio A, Pashkoulov D, Villani ME, Tramontano A, Benvenuto E. 2003. Engineering stable cytoplasmic intrabodies with designed specificity. *J. Mol. Biol.* 330: 323–332.
266. Dooley H, Flajnik MF, Porter AJ. 2003. Selection and characterization of naturally occuring single-domain (IgNAR) antibody fragments from immunized sharks by phage display. *Mol. Immun.* 40: 25–33.
267. Economides AN, Carpenter LR, Rudge JS, Wong V, Koehler-Stec EM, Hartnett C, Pyles EA, Xu X, Daly TJ, Young MR, Fandl JP, Lee F, Carver S, McNay J, Bailey K, Ramakanth S, Hutabrat R, Huang TT, Radziejewski C, Yancopoulos GD, Stahl N. 2003. Cytokine traps: multi-component, high-affinity blockers of cytokine action. *Nat. Med.* 9: 47–52.
268. Edwards BM, Barash SC, Main SH, Choi GH, Minter R, Ullrich S, Williams E, Du Fou L, Wilton J, Albert VR, Ruben SM, Vaughan TJ. 2003. The remarkable flexibility of the human antibody repertoire; isolation of over one thousand different antibodies to a single protein, BLyS. *J. Mol. Biol.* 334: 103–118.
269. Ehsani P, Meunier A, Nato F, Jafari A, Nato A, Lafaye P. 2003. Expression of anti human IL-4 and IL-6 scFvs in transgenic tobacco plants. *Plant Mol. Biol.* 52: 17–29.
270. Eniola AO, Willcox PJ, Hammer DA. 2003. Interplay between rolling and firm adhesion elucidated with a cell-free system engineered with two distint receptor-ligand pairs. *Biophys. J.* 85: 2720–2731.
271. Erickson-Miller CL, Freeman SD, Hopson CB, D'Alessio KJ, Fischer EI, Kikly KK, Abrahamson JA, Holmes SD, King AG. 2003. Characterization of Siglec-5 (CD170) expression and functional activity of anti-Siglec-5 antibodies on human phagocytes. *Exp. Hematol.* 31: 382–388.
272. Ewert S, Honegger A, Plückthun A. 2003. Structure-based improvement of the biophysical properties of immunoglobulin V_H domains with a generalizable approach. *Biochemistry* 42: 1517–1528.
273. Feldhaus MJ, Siegel RW, Opresko LK, Coleman JR, Weaver Feldhaus JM, Yeung YA, Cochran JR, Heinzelman P, Colby D, Swers J, Graff C, Wiley HS, Wittrup KD. 2003. Flow-cytometric isolation of human antibodies from a nonimmune *Saccharomyces cerevisiae* surface display library. *Nat. Biotechnol.* 21: 163–170.
274. Fitzpatick J, Manning BM, O'Kennedy R. 2003. Development of ELISA and sensor-based assays for the detection of ethynyl estradiol in bile. *Food Agric. Immun.* 15: 55–64.
275. Fotinopoulou A, Meyers T, Varley P, Turner G. 2003. Screening for glycosylation changes on recombinant human IgG using lectin methods. *Biotechnol. Appl. Biochem.* 37: 1–7.
276. Frisch C, Brocks B, Ostendorp R, Hoess A, von Rüden T, Kretzschmar T. 2003. From EST to IHC: human antibody pipeline for target research. *J. Immunol. Meth.* 275: 203–212.

277. Fromme B, Eftekhari P, Van Regenmortel M, Hoebeke J, Katz A, Millar R. 2003. A novel retro-inverso gonadotropin-releasing hormone (GnRH) immunogen elicits antibodies that neutralize the activity of native GnRH. *Endocrinology* **144**: 3262–3269.
278. Fung M, Lu M, Fure H, Sun C, Shi NY, Dou Y, Su J, Swanson X, Mollnes TE. 2003. Pre-neutralization of C5a-mediated effects by the monoclonal antibody 137-26 reacting with the C5a moiety of native C5 without preventing C5 cleavage. *Clin. Exp. Immunol.* **133**: 160–169.
279. Gonzales NR, Padlan EA, De Pascalis R, Schuck P, Schlom J, Kashmiri SVS. 2003. Minimizing immunogenicity of the SDR-grafted humanized antibody CC49 by genetic manipulation of the framework residues. *Mol. Immunol.* **40**: 337–349.
280. Gorlatova NV, Elokdah H, Fan K, Crandall DL, Lawrence DA. 2003. Mapping of a conformational epitope on plasminogen activator inhibitor-1 by random mutagenesis. *J. Biol. Chem.* **278**: 16329–16335.
281. Halin C, Gafner V, Villani ME, Borsi L, Berndt A, Kosmehl H, Zardi L, Neri D. 2003. Synergistic therapeutic effects of a tumor targeting antibody fragment, fused to interleukin 12 and to tumor necrosis factor α^1. *Cancer Res.* **63**: 3202–3210.
282. Hashiguchi S, Nakashima T, Nitani A, Yoshihara T, Yoshinaga K, Ito Y, Maeda Y, Sugimura K. 2003. Human FcεRIα-specific human single-chain Fv (scFv) antibody with antagonistic activity toward IgE/FcεRIα-binding. *J. Biochem.* **133**: 43–49.
283. Heine N, Ast T, Schneider-Mergener J, Reineke U, Germeroth L, Wenschuh H. 2003. Synthesis and screening of peptide arrays on cellulose membranes. *Tetrahedron* **59**: 9919–9930.
284. Helbig JH, König B, Knospe H, Bubert B, Yu C, Lück CP, Riboldi-Tunnicliffe A, Hilgenfeld R, Jacobs E, Hacker J, Fisher G. 2003. The PPIase active site of *Legionella pneumophila* Mip protein is involved in the infection of eukaryotic host cells. *Biol. Chem.* **384**: 125–137.
285. Helg A, Mueller MS, Joss A, Pöltl-Frank F, Stuart F, Robinson JA, Pluschke G. 2003. Comparison of analytical methods for the evaluation of antibody responses against epitopes of polymorphic protein antigens. *J. Immunol. Meth.* **276**: 19–31.
286. Herschhorn A, Admon A, Hizi A. 2003. Recombinant human antibodies against the reverse transcriptase of human immunodeficiency virus type-1. *Biochim. Biophys. Acta* **1648**: 154–163.
287. Horn IR, Nielsen MJ, Madsen M, Jacobsen C, Graversen JH, Moestrup SK, Jacobsen C. 2003. Generation of a haptoglobin-hemoglobin complex-specific Fab antibody blocking the binding of the complex to CD163. *Eur. J. Haematol.* **71**: 289–293.
288. Hugo N, Weidenhaupt M, Beukes M, Xu B, Janson J-C, Vernet T, Altschuh D. 2003. VL position 34 is a key determinant for the engineering of stable antibodies with fast dissociation rates. *Prot. Engng.* **16**: 381–386.
289. Jendreyko N, Popkov M, Beerli RR, Chung J, McGavern DB, Rader C, Barbas III CF. 2003. Intradiabodies, bispecific, tetravalent antibodies for the simultaneous functional knockout of two cell surface receptors. *J. Biol. Chem.* **278**: 47812–47819.
290. Karnani P, Kairemo K. 2003. The new tie-1 monoclonal antibodies dectect angiogenesis in metastatic malignancies. *Clin. Cancer Res.* **9**: 3827s–3830s.
291. Karnani P, Kairemo K. 2003. Targeting endothelial growth with monoclonal antibodies against tie-1 kinase in mouse models. *Clin. Cancer Res.* **9**: 3821s–3826s.
292. Kramer K, Rau D, Hock B. 2003. Comparison of affinity and immunochemical key data as measure for molecular antibody evolution. *Spectroscopy* **17**: 355–365.
293. Lantto J, Fletcher JM, Ohlin M. 2003. Binding characteristics determine the neutralizing potential of antibody fragments specific for antigenic domain 2 on glycoprotein B of human cytomegalovirus. *Virology* **305**: 201–209.
294. Lê LHD, Mayer M, Lederer F. 2003. Epitope mapping for the monoclonal antibody that inhibits intramolecular electron transfer in flavocytochrome b_2. *Biochem. J.* **373**: 115–123.
295. Li S, Takeda Y, Wragg S, Barrett J, Phillips A, Dynan WS. 2003. Modification of the ionizing radiation response in living cells by an scFv against the DNA-dependent protein kinase. *Nucl. Acids Res.* **31**: 5848–5857.
296. Li Y, Li H, Yang F, Smith-Gill SJ, Mariuzza RA. 2003. X-ray snapshots of the maturation of an antibody response to a protein antigen. *Nat. Struct. Biol.* **10**: 482–488.
297. Li Y, Nath N, Reichert WM. 2003. Parallel comparison of sandwich and direct label assay protocols on cytokine detection protein arrays. *Anal. Chem.* **75**: 5274–5281.
298. Li Y, Urrutia M, Smith-Gill SJ, Mariuzza RA. 2003. Dissection of binding interactions in the complex between the anti-lysozyme antibody HyHEL-63 and its antigen. *Biochemistry* **42**: 11–22.
299. Liaw PC, Ferrell G, Esmon CT. 2003. A monoclonal antibody against activated protein C allows rapid detection of activated protein C in plasma and reveals a calcium ion dependent epitope involved in factor Va inactivation. *J. Thromb. Haemost.* **1**: 662–670.
300. Liu Z, Panousis C, Smyth FE, Murphy R, Wirth V, Cartwright G, Johns TG, Scott AM. 2003. Generation of anti-idiotype antibodies for application in clinical immunotherapy laboratory analyses. *Hybrid Hybridomics* **22**: 219–228.
301. Long GL, Kjellberg M, Villoutreix BO, Stenflo J. 2003. Probing plasma clearance of the thrombin-antithrombin complex with a monoclonal antibody against the putative serpin-enzyme complex receptor-binding site. *Eur. J. Biochem.* **270**: 4059–4069.
302. Lu D, Jimenez X, Zhang H, Atkins A, Brennan L, Balderes P, Bohlen P, Witte L, Zhu Z. 2003. Di-diabody: a novel tetravalent bispecific antibody molecule by design. *J. Immunol. Meth.* **279**: 219–232.
303. Lu D, Shen J, Vil MD, Zhang H, Jimenez X, Bohlen P, Witte L, Zhu Z. 2003. Tailoring in vitro selection for a picomolar affinity human antibody directed against vascular enothelial growth factor receptor 2 for enhanced neutralizing activity. *J. Biol. Chem.* **278**: 43496–43507.
304. Marvin JS, Lowman HB. 2003. Redesigning an antibody fragment for faster association with its antigen. *Biochemistry* **42**: 7077–7083.
305. McDonagh CF, Beam KS, Wu GJS, Chen JH, Chace DF, Senter PD, Francisco JA. 2003. Improved yield and stability of L49-sFv-β-lactamase, a single-chain antibody fusion protein for anticancer prodrug activation, by protein engineering. *Bioconjug. Chem.* **14**: 860–869.
306. Ménez R, Bossus M, Muller BH, Sibaï G, Dalbon P, Ducancel F, Jolivet-Reynaud C, Stura EA. 2003. Crystal structure of a hydrophobic immunodominant antigenic site on hepatitis C virus core protein complexed to monoclonal antibody 19D9D6. *J. Immunol.* **170**: 1917–1924.
307. Metz B, Jiskoot W, Hennink WE, Crommelin DJA, Kersten GFA. 2003. Physicochemical and immunochemical techniques predict the quality of diphtheria toxoid vaccines. *Vaccine* **22**: 156–167.
308. Miller K, Meng G, Liu J, Hurst A, Hsei V, Wong W-L, Ekert R, Lawrence D, Sherwood S, DeForge L, Gaudreault J, Keller G, Sliwkowski M, Ashkenazi A, Presta L. 2003. Design, construction, and in vitro analyses of multivalent antibodies. *J. Immunol.* **170**: 4854–4861.
309. Misumi S, Endo M, Mukai R, Tachibana K, Umeda M, Honda T, Takamune N, Shoji S. 2003. A novel cyclic peptide immunization strategy for preventing HIV-1/AIDS infection and progression. *J. Biol. Chem.* **278**: 32335–32343.
310. Moghaddam A, Borgen T, Stacy J, Kausmally L, Simonsen B, Marvik OJ, Brekke OH, Braunagel M. 2003. Identification of scFv antibody fragments that specifically recognise the heroin metabolite 6-monoacetylmorphine but not morphine. *J. Immunol. Meth.* **280**: 139–155.
311. Morot-Gaudry-Talarmain Y, Rezaei H, Guermonprez L, Treguer E, Grosclaude J. 2003. Selective prion protein binding to synaptic components is modulated by oxidative and nitrosative changes induced by copper(II) and peroxynitrite in cholinergic synaptosomes, unveiling a role for calcineurin B and thioredoxin. *J. Neurochem.* **87**: 1456–1470.
312. Nevanen TK, Hellman M-L, Munck N, Wohlfahrt G, Koivula A, Söderlund H. 2003. Model-based mutagenesis to improve the enantioselective fraction properties of an antibody. *Prot. Engng.* **16**: 1089–1097.

313. Niederberger N, Holmberg K, Alam SM, Sakati W, Naramura M, Gu H, Gascoigne NRJ. 2003. Allelic exclusion of the TCR α-chain is an active process requiring TCR-mediated signaling and c-Cbl. *J. Immunol.* **170**: 4557–4563.
314. Ober RJ, Caves J, Sally WE. 2003. Analysis of exponential data using a noniterative technique: application to surface plasmon experiments. *Anal. Biochem.* **312**: 57–65.
315. Oda M, Kozono H, Morii H, Azuma T. 2003. Evidence of allosteric conformational changes in the antibody constant region upon antigen binding. *Int. Immunol.* **15**: 417–426.
316. Olsen RJ, Mazlo J, Koepsell SA, McKeithan TW, Hinrichs SH. 2003. Minimal structural elements of an inhibitory anti-ATF1/CREB single-chain antibody fragment (scFv41.4). *Hybrid Hybridomics* **22**: 65–77.
317. Paus E, Almåsbak H, Børmer OP, Warren DJ. 2003. A single-chain-Fv-based immunofluorometric assay specific for the CEA variant NCA-2. *J. Immunol. Meth.* **283**: 125–139.
318. Peter J-C, Briand J-P, Hoebeke J. 2003. How biotinylation can interfere with recognition: a surface plasmon resonance study of peptide-antibody interactions. *J. Immunol. Meth.* **274**: 149–158.
319. Pleass RJ, Ogun SA, McGuinness DH, van de Winkel JGJ, Holder AA, Woof JM. 2003. Novel antimalarial antibodies highlight the importance of the antibody Fc region in mediating protection. *Blood* **102**: 4424–4430.
320. Pleschberger M, Neubauer A, Egelseer EM, Weigert S, Lindner B, Sleytr UB, Muyldermans S, Sara M. 2003. Generation of a functional monomolecular protein lattice consisting of an S-layer fusion protein comprising the variable domain of a camel heavy chain antibody. *Bioconjug. Chem.* **14**: 440–448.
321. Popkov M, Mage RG, Alexander CB, Thundivalappil S, Barbas 3rd CF, Rader C. 2003. Rabbit immune repertoires as sources for therapeutic monoclonal antibodies: the impact of kappa allotype-correlated variation in cysteine content on antibody libraries selected by phage display. *J. Mol. Biol.* **325**: 325–335.
322. Portefaix J-M, Del Rio M, Granier C, Roquet F, Pau B, Navarro-Teulon I. 2003. Peptides derived from the two regulatory domains of p53 are recognized by two p53-activation antibodies. *Peptides* **24**: 339–345.
323. Power BE, Doughty L, Shapira DR, Burns JE, Bayly AM, Caine JM, Liu Z, Scott AM, Hudson PJ, Kortt AA. 2003. Noncovalent scFv multimers of tumor-targeting anti-Lewis^y hu3S193 humanized antibody. *Prot. Sci.* **12**: 734–747.
324. Rauchenberger R, Borges E, Thomassen-Wolf E, Rom E, Adar R, Yaniv Y, Malka M, Chumakov I, Kotzer S, Resnitzky D, Knappik A, Reiffert S, Prassler J, Jury K, Waldherr D, Bauer S, Kretzschmar T, Yayon A, Rothe C. 2003. Human combinatorial Fab library yielding specific and functional antibodies against the human fibroblast growth factor receptor 3. *J. Biol. Chem.* **278**: 38194–38205.
325. Rönnmark J, Kampf C, Asplund A, Höidén-Guthenberg I, Wester K, Pontén F, Uhlén M, Nygren P-Å. 2003. Affibody-β-galactosidase immunoconjugates produced as soluble fusion proteins in the *Escherichia coli* cytosol. *J. Immunol. Meth.* **281**: 149–160.
326. Rosovitz MJ, Schuck P, Varughese M, Chopra AP, Mehra V, Singh Y, McGinnis LM, Leppla SH. 2003. Alaninescanning mutations in domain 4 of anthrax toxin protective antigen reveal residues important for binding to the cellular receptor and to a neutralizing monoclonal antibody. *J. Biol. Chem.* **278**: 30936–30944.
327. Rossenu S, Leyman S, Dewitte D, Peelaers D, Jonckheere V, Van Troys M, Vandekerckhove J, Ampe C. 2003. A phage display-based method for determination of relative affinities of mutants. *J. Biol. Chem.* **278**: 16642–16650.
328. Rossi EA, Sharkey RM, McBride W, Karacay H, Zheng L, Hansen HJ, Goldenberg DM, Chang C-H. 2003. Development of new multivalent-bispecific agents for pretargeting tumor localization and therapy. *Clin. Cancer Res.* **9**: 3886s–3896s.
329. Rye K-A, Wee K, Curtiss LK, Bonnet DJ, Barter PJ. 2003. Apolipoprotein A-II inhibits high density lipoprotein remodeling and lipid-poor apolipoprotein A-I formation. *J. Biol. Chem.* **278**: 22530–22536.
330. Sagawa T, Oda M, Ishimura M, Furukawa K, Azuma T. 2003. Thermodynamic and kinetic aspects of antibody evolution during the immune response to hapten. *Mol. Immunol.* **39**: 801–808.
331. Santimaria M, Moscatelli G, Viale GL, Giovannoni L, Neri G, Viti F, Leprini A, Borsi L, Castellani P, Zardi L, Neri D, Riva P. 2003. Immunoscintigraphic detection of the ED-B domain of fibronectin, a marker of angiogenesis, in partients with cancer. *Clin. Cancer Res.* **9**: 571–579.
332. Schülke N, Varlamova OA, Donovan GP, Ma D, Gardner JP, Morrissey DM, Arrigale RR, Zhan C, Chodera AJ, Surowitz KG, Maddon PJ, Heston WDW, Olson WC. 2003. The homodimer of prostate-specific membrane antigen is a functional target for cancer therapy. *Proc. Natl. Acad. Sci. USA* **100**: 12590–12595.
333. Sepúlveda J, Jin H, Sblattero D, Bradbury A, Burrone OR. 2003. Binders based on dimerised immunoglobulin V_H domains. *J. Mol. Biol.* **333**: 355–365.
334. Sharkey RM, McBride W, Karacay H, Chang K, Griffiths GL, Hansen HJ, Goldenberg DM. 2003. A universal pretargeting system for cancer detection and therapy using bispecific antibody. *Cancer Res.* **63**: 354–363.
335. Shimizu T, Oda M, Azuma T. 2003. Estimation of the relative affinity of B cell receptor by flow cytometry. *J. Immunol. Meth.* **276**: 33–44.
336. Stacy JE, Kausmally L, Simonsen B, Nordgard SH, Alsøe L, Michaelsen TE, Brekke OH. 2003. Direct isolation of recombinant human antibodies against group B *Neisseria meningitidis* from scFv expression libraries. *J. Immunol. Meth.* **283**: 247–259.
337. Strand V, Aranow C, Cardiel MH, Alarcón-Segovia D, Furie R, Sherrer Y, Tumlin J, Wallace DJ, Crawford B. 2003. Improvements in health-related quality of life in systemic lupus erythematosus patients enrolled in a randomized clinical trial comparing LJP 394 treatment with placebo. *Lupus* **12**: 677–686.
338. Sun J, Pons J, Craik CS. 2003. Potent and selective inhibition of membrane-type serine protease 1 by human single-chain antibodies. *Biochemistry* **42**: 892–900.
339. Sydor JR, Scalf M, Sideris S, Mao GD, Pandey Y, Tan M, Mariano M, Moran MF, Nock S, Wagner P. 2003. Chipbased analysis of protein-protein interactions by fluorescence detection and on-chip immunoprecipitation combined with μLC-MS/MS analysis. *Anal. Chem.* **75**: 6163–6170.
340. Tachibana H, Watanabe K, Cheng X-J, Tsukamoto H, Kaneda Y, Takeuchi T, Ihara S, Petri J, William A. 2003. VH3 gene usage in neutralizing human antibodies specific for the *Entamoeba histolytica* Gal/GalNAc lectin heavy subunit. *Infect. Immun.* **71**: 4313–4319.
341. Tanaka T, Lobato MN, Rabbitts TH. 2003. Single domain intracellular antibodies: a minimal fragment for direct in vivo selection of antigen-specific Intrabodies. *J. Mol. Biol.* **331**: 1109–1120.
342. Tanaka T, Rabbitts TH. 2003. Intrabodies based on intracellular capture frameworks that bind the RAS protein with high affinity and impair oncogenic transformation. *EMBO J.* **22**: 1025–1035.
343. van den Beucken T, Pieters H, Steukers M, van der Vaart M, Ladner RC, Hoogenboom HR, Hufton SE. 2003. Affinity maturation of Fab antibody fragments by fluorescent-activated cell sorting of yeast-displayed libraries. *FEBS Lett.* **546**: 288–294.
344. van Koningsbruggen S, de Haard H, de Kievit P, Dirks RW, van Remoortere A, Groot AJ, van Engelen BGM, den Dunnen JT, Verrips CT, Frants RR, van der Maarel SM. 2003. Llama-derived phage display antibodies in the dissection of the human disease oculopharyngeal muscular dystrophy. *J. Immunol. Meth.* **279**: 149–161.
345. Vanhove B, Laflamme G, Coulon F, Mougin M, Vusio P, Haspot F, Tiollier J, Soulillou J-P. 2003. Selective blockade of CD28 and not CTLA-4 with a single-chain Fv-α_1-antitrypsin fusion antibody. *Blood* **102**: 564–570.
346. Venturi M, Hunte C. 2003. Monoclonal antibodies for the structural analysis of the Na^+/H^+ antiporter NhaA from *Escherichia coli*. *Biochim. Biophys. Acta* **1610**: 46–50.

347. Verheesen P, ten Haaft MR, Linder N, Verrips CT, de Haard JJW. 2003. Beneficial properties of single-domain antibody fragments for application in immunoaffinity purification and immuno-perfusion chromatography. *Biochim. Biophys. Acta* **1624**: 21–28.
348. Ward ES, Zhou J, Ghetie V, Ober RJ. 2003. Evidence to support the cellular mechanism involved in serum IgG homeostasis in humans. *Int. Immun.* **15**: 187–195.
349. Wild MA, Xin H, Maruyama T, Nolan MJ, Calveley PM, Malone JD, Wallace MR, Bowdish KS. 2003. Human antibodies from immunized donors are protective against anthrax toxin in *vivo*. *Nat. Biotech.* **21**: 1305–1306.
350. Wu C, Sakorafas P, Miller R, McCarthy D, Scesney S, Dixon R, Ghayur T. 2003. IL-18 receptor β-induced changes in the presentation of IL-18 binding sites affect ligand binding and signal transduction. *J. Immunol.* **170**: 5571–5577.
351. Yamaguchi H, Harada A. 2003. Antibody dendrimers. *Topics Curr. Chem.* **228**: 237–258.
352. Yang K, Basu A, Wang M, Chintala R, Hsieh M-C, Liu S, Hua J, Zhang Z, Zhou J, Li M, Phyu H, Petti G, Mendez M, Janjua H, Peng P, Longley C, Borowski V, Mehlig M, Filpula D. 2003. Tailoring structure-function and pharmacokinteic properties of single-chain Fv proteins by site-specific PEGylation. *Prot. Engng.* **16**: 761–770.
353. Yau KYF, Groves MAT, Li S, Sheedy C, Lee H, Tanha J, MacKenzie CR, Jermutus L, Hall JC. 2003. Selection of hapten-specific single-domain antibodies from a nonimmunized llama ribosome display library. *J. Immunol. Meth.* **281**: 161–175.
354. Yin J, Andryski SE, Beuscher IV AE, Stevens RC, Schultz PG. 2003. Structural evidence for substrate strain in antibody catalysis. *Proc. Natl. Acad. Sci. USA* **100**: 856–861.
355. Yin J, Beuscher IV AE, Andryski SE, Stevens RC, Schultz PG. 2003. Stuctural plasticity and the evolution of antibody affinity and specificity. *J. Mol. Biol.* **330**: 651–656.
356. Zeng G, Hu Z, Kinch MS, Pan C-X, Flockhart DA, Kao C, Gardner TA, Zhang S, Li L, Baldridge LA, Koch MO, Ulbright TM, Eble JN, Cheng L. 2003. High-level expression of EphA2 receptor tyrosine kinase in prostatic intraepithelial neoplasia. *Am. J. Pathol.* **163**: 2271–2276.
357. Zeytun A, Jeromin A, Scalettar BA, Waldo GS, Bradbury ARM. 2003. Fluorobodies combine GFP fluorescence with the binding characteristics of antibodies. *Nat. Biotech.* **21**: 1473–1479.
358. Zhu Z, Hattori K, Zhang H, Jimenez X, Ludwig DL, Dias S, Kussie P, Koo H, Kim HJ, Lu D, Liu M, Tejada R, Friedrich M, Bohlen P, Witte L, Rafii S. 2003. Inhibition of human leukemia in an animal model with human antibodies directed against vascular endothelial growth factor receptor 2. Correlation between antibody affinity and biological activity. *Leukemia* **17**: 604–611.

Receptors.

359. Anderluh G, Hong Q, Boetzel R, MacDonald C, Moore GR, Virden R, Lakey JH. 2003. Concerted folding and binding of a flexible colicin domain to its periplasmic receptor TolA. *J. Biol. Chem.* **278**: 21860–21868.
360. Andersen OM, Benhayon D, Curran T, Willnow TE. 2003. Differential binding of ligands to the apolipoprotein E receptor 2. *Biochemistry* **42**: 9355–9364.
361. Andersen OM, Yeung C-H, Vorum H, Wellner M, Andreassen TK, Erdmann B, Mueller E-C, Herz J, Otto A, Cooper TG, Willnow TE. 2003. Essential role of the apolipoprotein E receptor-2 in sperm development. *J. Biol. Chem.* **278**: 23989–23995.
362. Bdeir K, Kuo A, Sachais BS, Rux AH, Bdeir Y, Mazar A, Al-Roof Higazi A, Cines DB. 2003. The kringle stabilizes urokinase binding to the urokinase receptor. *Blood* **102**: 3600–3608.
363. Bernat B, Pal G, Sun M, Kossiakoff AA. 2003. Determination of the energetics governing the regulatory step in growth hormone-induced receptor homodimerization. *Proc. Natl. Acad. Sci. USA* **100**: 952–957.
364. Bitard J, Daburon S, Duplomb L, Blanchard F, Vuisio P, Jacques Y, Godard A, Heath JK, Moreau J-F, Taupin J-L. 2003. Mutations in the immunoglobulin-like domain of gp190, the leukemia inhibitory factor (LIF) receptor, increase or decrease its affinity for LIF. *J. Biol. Chem.* **278**: 16253–16261.
365. Boulter JM, Glick M, Todorov PT, Baston E, Sami M, Rizkallah P, Jakobsen BK. 2003. Stable, soluble T-cell receptor molecules for crystallization and therapeutics. *Prot. Engng.* **16**: 707–711.
366. Buslepp J, Kerry SE, Loftus D, Frelinger JA, Appella E, Collins EJ. 2003. High affinity xenoreactive TCR:MHC interaction recruits CD8 in absence of binding to MHC. *J. Immunol.* **170**: 373–383.
367. Butala HD, Ramakrishnan A, Sadana A. 2003. A mathematical analysis using fractals for binding interactions of estrogen receptors to different ligands on biosensor surfaces. *Sens. Actuat. B* **88**: 266–280.
368. Butala HD, Sadana A. 2003. A fractal analysis of analyte-estrogen receptor binding and dissociation kinetics using biosensors: environmental effects. *J. Colloid Interface Sci.* **263**: 420–431.
369. Chen L, Estève E, Sabatier J-M, Ronjat M, De Waard M, Allen PD, Pessah IN. 2003. Maurocalcine and peptide A stabilize distinct subconductance states of ryanodine receptor type 1, revealing a proportional gating mechanism. *J. Biol. Chem.* **278**: 16095–16106.
370. Chen M-C, Hwang M-J, Chou Y-C, Chen W-H, Cheng G, Nakano H, Luh T-Y, Mai S-C, Hsieh S-L. 2003. The role of apoptosis signal-regulating kinase 1 in lymphotoxin-β receptor-mediated cell death. *J. Biol. Chem.* **278**: 16073–16081.
371. Cheskis BJ, McKenna NJ, Wong C-W, Wong J, Komm B, Lyttle CR, O'Malley BW. 2003. Hierarchical affinities and a bipartite interaction model for estrogen receptor isoforms and full length steroid receptor coactivator (SRC/p160) family members. *J. Biol. Chem.* **278**: 13271–13277.
372. Choi EM-L, Chen J-L, Wooldridge L, Sallo M, Lissina A, Lissin N, Hermans IF, Silk JD, Mirza F, Palmowski MJ, Dunbar PR, Jakobsen BK, Sewell AK, Cerundolo V. 2003. High avidity antigen-specific CTL identifies by CD8-independent tetramer staining. *J. Immunol.* **171**: 5116–5123.
373. Conticello SG, Kowalsman ND, Jacobsen C, Yudkovsky G, Sato K, Elazar Z, Munck Petersen C, Aronheim A, Falnzilber M. 2003. The pro-domain of a secreted hydrophobic mini-protein facilitates its export from the endoplasmic reticulum by hitchhiking on sorting receptors. *J. Biol. Chem.* **278**: 26311–26314.
374. Dam J, Guan R, Natarajan K, Dimasi N, Chlewicki LK, Kranz DM, Schuck P, Margulies DH, Mariuzza RA. 2003. Variable MHC class I engagement by Ly49 natural killer cell receptors demonstrated by the crystal structure of Ly49C bound to H-2K^b. *Nat. Immunol.* **4**: 1213–1222.
375. Datta A, Stone MJ. 2003. Soluble mimics of a chemokine receptor: chemokine binding by receptor elements juxtaposed on a soluble scaffold. *Prot. Sci.* **12**: 2482–2491.
376. Davis S, Papadopoulos N, Aldrich TH, Maisonpierre PC, Huang T, Kovac L, Xu A, Leidich R, Radziejewska E, Rafique A, Goldberg J, Jain V, Bailey K, Karow M, Fandl J, Samuelsson SJ, Ioffe E, Rudge JS, Daly TJ, Radziejewski C, Yancopoulos GD. 2003. Angiopoietins have distinct modular domains essential for receptor binding, dimerization and superclustering. *Nat. Struct. Biol.* **10**: 38–44.
377. De Crescenzo G, Pham PL, Durocher Y, O'Connor-McCourt MD. 2003. Transforming growth factor-beta (TGF-β) binding to the extracellular domain of the type II TGF-β receptor: receptor capture on a biosensor surface using a new coiled-coil capture system demonstrates that avidity contributes significantly to high affinity binding. *J. Mol. Biol.* **328**: 1173–1183.
378. Duplomb L, Chaigne-Delalande B, Vusio P, Raher S, Jacques Y, Godard A, Blanchard F. 2003. Soluble mannose 6-phosphate/insulin-like growth factor II (IGFII) receptor inhibits interleukin-6-type cytokine-dependent proliferation by neutralization of IGF-II. *Endocrinology* **144**: 5381–5389.
379. Faure G, Čopič A, Porrier SL, Gubenšek F, Bon C, Kriaj I. 2003. Crotoxin acceptor protein isolated from torpedo electric organ: binding properties to crotoxin by surface plasmon resonance. *Toxicon* **41**: 509–517.
380. Fedosov SN, Laursen NB, Nexø E, Moestrup SK, Petersen TE, Jensen EØ, Berglund L. 2003. Human intrinsic factor expressed in the plant *Arabidopsis thaliana*. *Eur. J. Biochem.* **270**: 3362–3367.

381. Ferguson KM, Berger MB, Mendrola JM, Cho H-S, Leahy DJ, Lemmon MA. 2003. EGF activates its receptor by removing interactions that autoinhibit ectodomain dimerization. *Mol. Cell* **11**: 507–517.
382. Fujikawa A, Shirasaka D, Yamamoto S, Ota H, Yahiro K, Fukada M, Shintani T, Wada A, Aoyama N, Hirayama T, Fukamachi H, Noda M. 2003. Mice deficient in protein tyrosine phosphatase receptor type Z are resistant to gastric ulcer induction by VacA of *Helicobacter pylori*. *Nat. Genetics* **33**: 375–381.
383. Gburek J, Birn H, Verroust PJ, Goj B, Jacobsen C, Moestrup SK, Willnow TE, Christensen EL. 2003. Renal uptake of myoglobin is mediated by the endocytic receptors megalin and cubilin. *Am. J. Physiol. Renal Physiol.* **285**: F451–F458.
384. Giannetti AM, Snow PM, Zak O, Björkman PJ. 2003. Mechanism for multiple ligand recognition by the human transferrin receptor. *PLoS Biology* **1**: 341–350.
385. Greenwald J, Groppe J, Gray P, Wiater E, Kwiatkowski W, Vale W, Choe S. 2003. The BMP7/ActRII extracellular domain complex provides new insights into the cooperative nature of receptor assembly. *Mol. Cell* **11**: 605–617.
386. Harmegnies D, Wang X-M, Vandenbussche P, Leon A, Vusio P, Grötzinger J, Jacques Y, Goormaghtigh E, Devreese B, Content J. 2003. Characterization of a potent human interleukin-11 agonist. *Biochem. J.* **375**: 23–32.
387. Hentschke M, Schulze C, Süsens U, Borgmeyer U. 2003. Characterization of calmodulin binding to the orphan nuclear receptor ERRγ. *Biol. Chem.* **384**: 473–482.
388. Hermey G, Keat SJ, Madsen P, Jacobsen C, Petersen CM, Gliemann J. 2003. Characterization of sorCS1, an alternatively spliced receptor with completely different cytoplasmic domains that mediate different trafficking in cells. *J. Biol. Chem.* **278**: 7390–7396.
389. Herr AB, White CL, Milburn C, Wu C, Bjorkman PJ. 2003. Bivalent binding of IgA1 to FcαRI suggests a mechanism for cytokine activation of IgA phagocytosis. *J. Mol. Biol.* **327**: 645–657.
390. Holler PD, Chlewicki LK, Kranz DM. 2003. TCRs with high affinity for foreign pMHC show self-reactivity. *Nat. Immunol.* **4**: 55–62.
391. Holler PD, Kranz DM. 2003. Quantitative analysis of the contribution of TCR/pepMHC affinity and CD8 to T cell activation. *Immunity* **18**: 255–264.
392. Jisa E, Jungbauer A. 2003. Kinetic analysis of estrogen receptor homo- and heterodimerization in vitro. *J. Steroid Biochem. Mol. Biol.* **84**: 141–148.
393. Karlsson F, Borrebaeck CAK, Nilsson N, Malmborg-Hager A-C. 2003. The mechanism of bacterial infection by filamentous phages involves molecular interactions between To1A and phage protein 3 domains. *J. Bacteriol.* **185**: 2628–2634.
394. Kato Z, Jee J, Shikano H, Mishima M, Ohki I, Ohnishi H, Li A, Hashimoto K, Matsukuma E, Omoya K, Yamamoto Y, Yoneda T, Hara T, Kondo N, Shirakawa M. 2003. The structure and binding mode of Interleukin-18. *Nat. Struct. Biol.* **10**: 966–971.
395. Kerry SE, Buslepp J, Cramer LA, Maile R, Hensley LL, Nielsen AI, Kavathas P, Vilen BJ, Collins EJ, Frelinger JA. 2003. Interplay between TCR affinity and necessity of coreceptor ligation: high-affinity peptide-MHC/TCR interaction overcomes lack of CD8 engagement. *J. Immunol.* **171**: 4493–4503.
396. Kim KS, Hong Y-K, Joe YA, Lee Y, Shin J-Y, Park H-E, Lee I-H, Lee S-Y, Kang D-K, Chang S-I, Chung SI. 2003. Anti-angiogenic activity of the recombinant kringle domain of urokinase and its specific entry into endothelial cells. *J. Biol. Chem.* **278**: 11449–11456.
397. Kim KS, Hong Y-K, Lee Y, Shin J-Y, Chang S-I, Chung SI, Joe YA. 2003. Differential inhibition of endothelial cell proliferation and migration by urokinase subdomains: amino-terminal fragment and kringle domain. *Exp. Mol. Med.* **35**: 578–585.
398. Kiselyov VV, Skladchikova G, Hinsby AM, Jensen PH, Kulahin N, Soroka V, Pedersen N, Tsetlin V, Poulsen FM, Berezin V, Bock E. 2003. Structural basis for a direct interaction between FGFR1 and NCAM and evidence for a regulatory role of ATP. *Structure (Camb.)* **11**: 691–701.
399. Krell T, Renauld-Mongenie G, Nicolai M-C, Fraysse S, Chevalier M, Bérard Y, Oakhill J, Evans RW, Gorringe A, Lissolo L. 2003. Insight into the structure and function of the transferrin receptor from *Neisseria meningitidis* using microcalorimetric techniques. *J. Biol. Chem.* **278**: 14712–14722.
400. Krogsgaard M, Prado N, Adams EJ, He X-l, Chow D-C, Wilson DB, Garcia KC, Davis MM. 2003. Evidence that structural rearrangements and/or flexibility during TCR binding can contribute to T cell activation. *Mol. Cell* **12**: 1367–1378.
401. Lee K, Jin X, Zhang K, Copertino L, Andrews L, Baker-Malcolm J, Geagan L, Qiu H, Seiger K, Barngrover D, McPherson JM, Edmunds T. 2003. A biochemical and pharmacological comparison of enzyme replacement therapies for the glycolipid storage disorder Fabry disease. *Glycobiology* **13**: 305–313.
402. Liu Y, Hong X, Kappler J, Jiang L, Zhang R, Xu L, Pan C-H, Martin WE, Murphy RC, Shu H-B, Dai S, Zhang G. 2003. Ligand-receptor binding revealed by the TNF family member TALL-1. *Nature* **423**: 49–56.
403. Lozach P-Y, Lortat-Jacob H, de Lacroix de Lavalette A, Staropoli I, Foung S, Amara A, Houlès C, Fieschi F, Schwartz O, Virelizier J-L, Arenzana-Seisdedos F, Altmeyer R. 2003. DC-SIGN and L-SIGN are high affinity binding receptors for hepatitis C virus glycoprotein E2. *J. Biol. Chem.* **278**: 20358–20366.
404. Machner MP, Frese S, Schubert W-D, Orian-Rousseau V, Gherardi E, Wehland J, Niemann HH, Heniz DW. 2003. Aromatic amino acids at the surface of InlB are essential for host cell invasion by *Listeria monocytogenes*. *Mol. Microbiol.* **48**: 1525–1536.
405. Mallet-Designe VI, Stratmann T, Homann D, Carbone F, Oldstone MB, Teyton L. 2003. Detection of low-avidity CD4+ T cells using recombinant artificial APC: following the antiovalbumin immune response. *J. Immunol.* **170**: 123–131.
406. Martin L, Stricher F, Missé D, Sironi F, Pugnière M, Barthe P, Prado-Gotor R, Freulon I, Magne X, Roumestand C, Ménez A, Lusso P, Veas F, Vita C. 2003. Rational design of a CD4 mimic that inhibits HIV-1 entry and exposes cryptic neutralization epitopes. *Nat. Biotechnol.* **21**: 71–76.
407. Martinez LO, Jacquet S, Esteve J-P, Rolland C, Cabezón E, Champagne E, Pineau T, Georgeaud V, Walker JE, Tercé F, Collet X, Perret B, Barbaras R. 2003. Ectopic β-chain of ATP synthase is an apolipoprotein A-I receptor in hepatic HDL endocytosis. *Nature* **421**: 75–79.
408. Matsumoto M, Misawa S, Tsumoto K, Kumagai I, Hayashi H, Kobayashi Y. 2003. On-column refolding and characterization of soluble human interleukin-15 receptor α-chain produced in *Escherichia coli*. *Prot. Exp. Purif.* **31**: 64–71.
409. McCleverty CJ, Liddington RC. 2003. Engineered allosteric mutants of the integrin $\alpha M\beta 2$ I domain: structural and functional studies. *Biochem. J.* **372**: 121–127.
410. McCormick JK, Tripp TJ, Llera AS, Sundberg EJ, Dinges MM, Mariuzza RA, Schlievert PM. 2003. Functional analysis of the TCR binding domain of toxic shock syndrome toxin-1 predicts further diversity in MHC class II/superantigen/TCR ternary complexes. *J. Immunol.* **171**: 1385–1392.
411. McFarland BJ, Kortemme T, Yu SF, Backer D, Strong RK. 2003. Symmetry recognizing asymmetry: analysis of the interactions between the C-type lectin-like immunoreceptor NKG2D and MHC class I-like ligands. *Structure* **11**: 411–422.
412. McFarland BJ, Strong RK. 2003. Thermodynamic analysis of degenerate recognition by the NKG2D immunoreceptor: not induced fit but rigid adaptation. *Immunity* **19**: 803–812.
413. McMahan RH, Watson L, Meza-Romero R, Burrows GG, Bourdette DN, Buenafe AC. 2003. Production, characterization, and immunogenicity of a soluble rat single chain T cell receptor specific for an encephalitogenic peptide. *J. Biol. Chem.* **278**: 30961–30970.
414. Milne RSB, Hanna SL, Rux AH, Willis SH, Cohen GH, Eisenberg RJ. 2003. Function of herpes simplex virus type 1 gD mutants with different receptor-binding affinities in virus entry and fusion. *J. Virol.* **77**: 8962–8972.
415. Nuttall SD, Krishnan UV, Doughty L, Pearson K, Ryan MT, Hoogenraad NJ, Hattarki M, Carmichael JA, Irving RA, Hudson PJ. 2003. Isolation and characterization of an IgNAR variable domain specific for the human mitochondrial translocase receptor Tom70. *Eur. J. Biochem.* **270**: 3543–3554.
416. Ohmachi S, Mikami T, Konishi M, Miyake A, Itoh N. 2003. Preferential neurotrophic activity of fibroblast growth factor-20 for dopaminergic neurons through fibroblast growth factor receptor-1c. *J. Neurosci. Res.* **72**: 436–443.
417. Petersen HH, Hilpert J, Militz D, Zandler V, Jacobsen C, Roebroek AJM, Willnow TE. 2003. Functional interaction of megalin

with the megalin-binding protein (MegBP), a novel tetratrico peptide repeat-containing adaptor molecule. *J. Cell Sci.* **116**: 453–461.
418. Reiser J-B, Darnault C, Grégoire C, Mosser T, Mazza G, Kearney A, van der Merwe PA, Fontecilla-Camps JC, Housset D, Malissen B. 2003. CDR3 loop flexibility contributes to the degeneracy of TCR recognition. *Nat. Immunol.* **4**: 241–247.
419. Sarkar CA, Lowenhaupt K, Wang PJ, Horan T, Lauffenburger DA. 2003. Parsing the effects of binding, signaling, and trafficking on the mitogenic potencies of granulocyte colony-stimulating factor analogues. *Biotechnol. Prog.* **19**: 955–964.
420. Schweickhardt RL, Jiang X, Garone LM, Brondyk WH. 2003. Structure-expression relationship of tumor necrosis factor receptor mutants that increase expression. *J. Biol. Chem.* **278**: 28961–28967.
421. Shatkina L, Mink S, Rogatsch H, Klocker H, Langer G, Nestl A, Cato ACB. 2003. The cochaperone Bag-1L enhances androgen receptor action via interaction with the NH2-terminal region of the receptor. *Mol. Cell. Biol.* **23**: 7189–7197.
422. Shimaoka M, Salas A, Yang W, Weitz-Schmidt G, Springer TA. 2003. Small molecule integrin antagonists that bind to the β_2 subunit I-like domain and activate signals in one direction and block them in the other. *Immunity* **19**: 391–402.
423. Shimaoka M, Xiao T, Liu J-H, Yang Y, Dong Y, Jun CD, McCormack A, Zhang R, Joachimiak A, Takagi J, Wang J-H, Springer TA. 2003. Structures of the αL I domain and its complex with ICAM-1 reveal a shapeshifting pathway for integrin regulation. *Cell* **112**: 99–111.
424. Shiroishi M, Tsumoto K, Amano K, Shirakihara Y, Colonna M, Braud VM, Allan DSJ, Makadzange A, Rowland-Jones S, Willcox B, Jones EY, van der Merwe PA, Kumagai I, Maenaka K. 2003. Human inhibitory receptors Ig-like transcript 2 (ILT2) and ILT4 compete with CD8 for MHC class I binding and bind preferentially to HLA-G. *Proc. Natl. Acad. Sci. USA* **100**: 8856–8861.
425. Sim B-C, Holmberg K, Sidobre S, Naidenko O, Niederberger N, Marine SD, Kronenberg M, Gascoigne NRJ. 2003. Surprisingly minor influence of TRAV11 (Vα14) polymorphism on NK T-receptor mCD1/α-galactosylceramide binding kinetics. *Immunogenetics* **54**: 874–883.
426. Smith DE, Hanna R, Friend D, Moore H, Chen H, Farese A, MacVittie TJ, Virca GD, Sims JE. 2003. The soluble form of IL-1 receptor accessory protein enhances the ability of soluble type II IL-1 receptor to inhibit IL-1 action. *Immunity* **18**: 87–96.
427. Song H, He C, Knaak C, Guthridge JM, Holers VM, Tomlinson S. 2003. Complement receptor 2-mediated targeting of complement inhibitors to sites of complement activation. *J. Clin. Invest.* **111**: 1875–1885.
428. Srivastava IK, Stamatatos L, Kan E, Vajdy M, Lian Y, Hilt S, Martin L, Vita C, Zhu P, Roux KH, Vojtech L, Montefiori DC, Donnelly J, Ulmer JB, Barnett SW. 2003. Purification, characterization, and immunogenicity of a soluble trimeric envelope protein containing a partial deletion of the V2 loop derived from SF162, an R5-tropic human immunodeficiency virus type 1 isolate. *J. Virol.* **77**: 11244–11259.
429. Steele CR, Van Remoortere KC, Hayday AC. 2003. Production of a soluble γδ T-cell receptor to identify ligands for the murine intestinal intraepithelial γδ T cell population. *J. Chromatogr. B* **786**: 297–304.
430. Stenlund P, Babcock GJ, Sodroski J, Myszka DG. 2003. Capture and reconstitution of G protein-coupled receptors on a biosensor surface. *Anal. Biochem.* **316**: 243–250.
431. Stratmann T, Martin-Orozco N, Mallet-Designe V, Poirot L, McGavern D, Losyev G, Dobbs CM, Oldstone MBA, Yoshida K, Kikutani H, Mathis D, Benoist C, Haskins K, Teyton L. 2003. Susceptible MHC alleles, not background genes, select an autoimmune T cell reactivity. *J. Clin. Invest.* **112**: 902–914.
432. Swietnicki W, Barnie AM, Dyas BK, Ulrich RG. 2003. Zinc binding and dimerization of *Streptococcus pyogenes* pyrogenic exotoxin C are not essential for T-cell stimulation. *J. Biol. Chem.* **278**: 9885–9895.
433. Tzameli I, Chua SS, Cheskis B, Moore DD. 2003. Complex effects of rexinoids on ligand dependent activation or inhibition of the xenobiotic receptor, CAR. *Nucl. Recept.* **1**: 2.
434. Ueda Y, Yamagishi T, Samata K, Ikeya H, Hirayama N, Takashima H, Nakaike S, Tanaka M, Saiki I. 2003. A novel low molecular weight antagonist of vascular endothelial growth factor receptor binding: VGA1155. *Mol. Cancer Ther.* **2**: 1105–1111.
435. Vella F, Thielens NM, Bersch B, Arlaud GJ, Frachet P. 2003. A recombinant chimeric epidermal growth factorlike module with high binding affinity for integrins. *J. Biol. Chem.* **278**: 19834–19843.
436. Vollenbroeker B, Fobker M, Specht B, Bartetzko N, Erren M, Spener F, Hohage H. 2003. Receptor assay based on surface plasmon resonance for the assessment of the complex formation activity of cyclosporin A and its metabolites. *Int. J. Clin. Pharmac. Ther.* **41**: 248–260.
437. Vorup-Jensen T, Ostermeier C, Shimaoka M, Hommel U, Springer TA. 2003. Structure and allosteric regulation of the $\alpha X\beta 2$ integrin I domain. *Proc. Natl. Acad. Sci. USA* **100**: 1873–1878.
438. Walsh STR, Jevitts LM, Sylvester JE, Kossiakoff AA. 2003. Site2 binding energetics of the regulatory step of growth hormone-induced receptor homodimerization. *Prot. Sci.* **12**: 1960–1970.
439. Wang S, Bajorath J, Flies DB, Dong H, Honjo T, Chen L. 2003. Molecular modeling and functional mapping of B7-H1 and B7-DC uncouple costimulatory function from PD-1 interaction. *J. Exp. Med.* **197**: 1083–1091.
440. Weber ANR, Tauszig-Delamasure S, Hoffmann JA, Lelievre E, Gascan H, Ray KP, Morse MA, Imler J-L, Gay NJ. 2003. Binding of the drosophila cytokine spatzle to toll is direct and establishes signaling. *Nat. Immunol.* **4**: 794–800.
441. Weber FE, Schmökel H, Oelgeschläger M, Nickel J, Maly FE, Hortschansky P, Grätz KW. 2003. Deletion mutants of BMP folding variants act as BMP antagonists and are efficient inhibitors for heterotopic ossification. *J. Bone Miner. Res.* **18**: 2142–2151.
442. Wines BD, Gavin A, Powell MS, Steinitz M, Buchanan RRC, Hogarth PM. 2003. Soluble FcγRIIa inhibits rheumatoid factor binding to immune complexes. *Immunology* **109**: 246–254.
443. Wright GJ, Cherwinski H, Foster-Cuevas M, Brooke G, Puklavec MJ, Bigler M, Song Y, Jenmalm M, Gorman D, McClanahan T, Liu M-R, Brown MH, Sedgwick JD, Phillips JH, Barclay AN. 2003. Characterization of the CD200 receptor family in mice and humans and their interactions with CD200. *J. Immunol.* **171**: 3034–3046.
444. Wu Z, Van Ryk D, Davis C, Abrams WR, Chaiken I, Magnani J, Malamud D. 2003. Salivary agglutinin inhibits HIV type 1 infectivity through interaction with viral glycoprotein 120. *AIDS Res. Hum. Retroviruses* **19**: 201–209.
445. Xie Q, Matsunaga S, Shi X, Ogawa S, Niimi S, Wen Z, Tokuyasu K, Machida S. 2003. Refolding and characterization of the functional ligand-binding domain of human lectin-like oxidized LDL receptor. *Prot. Exp. Purif.* **32**: 68–74.
446. Yamamoto Y, Tsutsumi Y, Yoshioka Y, Nishibata T, Kobayashi K, Okamoto T, Mukai Y, Shimizu T, Nakagawa S, Nagata S, Mayumi T. 2003. Site-specific PEGylation of a lysine-deficient TNF-α with full bioactivity. *Nat. Biotech.* **21**: 546–552.
447. Yamazaki Y, Takani K, Atoda H, Morita T. 2003. Snake venom vascular endothelial growth factors (VEGFs) exhibit potent activity through their specific recognition of KDR (VEGF receptor 2). *J. Biol. Chem.* **278**: 51985–51988.
448. Yang J, Swaminathan CP, Huang Y, Guan R, Cho S, Kieke MC, Kranz DM, Mariuzza RA, Sundberg EJ. 2003. Dissecting cooperative and additive binding energetics in the affinity maturation pathway of a protein-protein interface. *J. Biol. Chem.* **278**: 50412–50421.
449. Youngnak P, Kozono Y, Kozono H, Iwai H, Otsuki N, Jin H, Omura K, Yagita H, Pardoll DM, Chen L, Azuma M. 2003. Differential binding properties of B7-H1 and B7-DC to programmed death-1. *Biochem. Biophys. Res. Commun.* **307**: 672–677.
450. Zhang J-L, Foster D, Sebald W. 2003. Human IL-21 and IL-4 bind to partially overlapping epitopes of common γ-chain. *Biochem. Biophys. Res. Commun.* **300**: 291–296.
451. Zhou J, Johnson JE, Ghetie V, Ober RJ, Ward ES. 2003. Generation of mutated variants of the human form of the MHC class I-related receptor, FcRn, with increased affinity for mouse immunoglobulin G. *J. Mol. Biol.* **332**: 901–913.

Peptides.
452. Ahmad KF, Melnick A, Lax S, Bouchard D, Liu J, Kiang C-L, Mayer S, Takahashi S, Licht JD, Privé GG. 2003. Mechanism of SMRT corepressor recruitment by the BCL6 BTB domain. *Mol. Cell* **12**: 1551–1564.
453. Amin A, Zaccardi J, Mullen S, Olland S, Orlowski M, Feld B, Labonte P, Mak P. 2003. Identification of constrained peptides that bind to and preferentially inhibit the activity of the hepatitis C viral RNA-dependent RNA polymerase. *Virology* **313**: 158–169.
454. Anderson ME, Siahaan TJ. 2003. Mechanism of binding and internalization of ICAM-1-derived cyclic peptides by LFA-1 on the surface of T cells: a potential method for targeted drug delivery. *Pharm. Res.* **20**: 1523–1532.
455. Asher C, Sinha I, Garty H. 2003. Characterization of the interactions between Nedd4–2, ENaC, and *sgk*-1 using surface plasmon resonance. *Biochim. Biophys. Acta* **1612**: 59–64.
456. Ashraf SS, Anderson E, Fredericks Z, Duke K, Hamilton PT. 2003. Identification and characterization of peptide probes directed against PKCβ conformations. *J. Pept. Res.* **61**: 263–273.
457. Beinke S, Deka J, Lang V, Belich MP, Walker PA, Howell S, Smerdon SJ, Gamblin SJ, Ley SC. 2003. NF-κB1 p105 negatively regulates TPL-2 MEK kinase activity. *Mol. Cell. Biol.* **23**: 4739–4752.
458. Boudeau J, Baas AF, Deak M, Morrice NA, Kieloch A, Schutkowski M, Prescott AR, Clevers HC, Alessi DR. 2003. MO25α/β interact with STRADα/β enchancing their ability to bind, activate and localize LKB1 in the cytoplasm. *EMBO J.* **22**: 5102–5114.
459. Brychzy A, Rein T, Winklhofer KF, Hartl FU, Young JC, Obermann WMJ. 2003. Cofactor Tpr2 combines two TPR domains and a J domain to regulate the Hsp70/Hsp90 chaperone system. *EMBO J.* **22**: 3613–3623.
460. Casset F, Roux F, Mouchet P, Bes C, Chardes T, Granier C, Mani J-C, Pugnière M, Laune D, Pau B, Kaczorek M, Lahana R, Rees A. 2003. A peptide mimetic of an anti-CD4 monoclonal antibody by rational design. *Biochem. Biophys. Res. Commun.* **307**: 198–205.
461. Chiva C, Barthe P, Codina A, Gairí M, Molina F, Granier C, Pugnière M, Inui T, Nishio H, Nishiuchi Y, Kimura T, Sakakibara S, Albericio F, Giralt E. 2003. Synthesis and NMR structure of p41icf, a potent inhibitor of human cathepsin L. *J. Am. Chem. Soc.* **125**: 1508–1517.
462. Clements CS, Reid HH, Beddoe T, Tynan FE, Perugini MA, Johns TG, Bernard CCA, Rossjohn J. 2003. The crystal structure of myelin oligodendrocyte glycoprotein, a key autoantigen in multiple sclerosis. *Proc. Natl. Acad. Sci. USA* **100**: 11059–11064.
463. Consonni R, Arosio I, Recca T, Longhi R, Colombo G, Vanoni M. 2003. Structure determination and dynamics of peptides overlapping the catalytic hairpin of the ras-specific GEF Cdc25^{Mm}. *Biochemistry* **42**: 12154–12162.
464. Cottingham MG, Voskuil JLA, Vaux DJT. 2003. The intact human acetylcholinesterase C-terminal oligomerization domain is α-helical *in situ* and in isolation, but a shorter fragment forms β-sheet-rich amyloid fibrils and protofibrillar oligomers. *Biochemistry* **42**: 10863–10873.
465. De Crescenzo G, Litowski JR, Hodges RS, O'Connor-McCourt MD. 2003. Real-time monitoring of the interactions of two-stranded *de novo* designed coiled-coils: effect of chain length on the kinetic and thermodynamic constants of binding. *Biochemistry* **42**: 1754–1763.
466. Dong L, Hülsmeyer M, Dürkop H, Hansen HP, Schneider-Mergener J, Ziegler A, Uchanska-Ziegler B. 2003. Human CD30: structural implications from epitope mapping and modeling studies. *J. Mol. Recognit.* **16**: 28–36.
467. Ehlers R, Ustinov V, Chen Z, Zhang X, Rao R, Luscinskas FW, Lopez J, Plow E, Simon DI. 2003. Targeting platelet-leukocyte interactions: identification of the integrin Mac-1 binding site for the platelet counter receptor glycoprotein Ibα. *J. Exp. Med.* **198**: 1077–1088.
468. Einhauer A, Jungbauer A. 2003. Complex formation of a calcium-dependent antibody: a thermodynamical consideration. *J. Chromatogr. A* **1009**: 81–87.
469. Elewaut D, Lawton AP, Nagarajan NA, Maverakis E, Khurana A, Honing S, Benedict CA, Sercarz E, Bakke O, Kroneneberg M, Prigozy TL. 2003. The adaptor protein AP-3 is required for CD1d-mediated antigen presentation of glycosphingolipids and development of Vá14*i* NKT cells. *J. Exp. Med.* **198**: 1133–1146.
470. Fairlie WD, De Souza D, Nichola NA, Baca M. 2003. Negative regulation of gp130 signalling mediated through tyrosine-757 is not dependent on the recruitment of SHP2. *Biochem. J.* **372**: 495–502.
471. Fang M, Tao Y-X, He F, Zhang M, Levine CF, Mao P, Tao F, Chou C-L, Sadegh-Nasseri S, Johns RA. 2003. Synaptic PDZ domain-mediated protein interactions are disrupted by inhalational anesthetics. *J. Biol. Chem.* **278**: 36669–36675.
472. Ferjoux G, Lopez F, Esteve J-P, Ferrand A, Vivier E, Vely F, Saint-Laurent N, Pradayrol L, Buscail L, Susini C. 2003. Critical role of Src and SHP-2 in sst2 somatostatin receptor-mediated activation of SHP-1 and inhibition of cell proliferation. *Mol. Biol. Cell* **14**: 3911–3928.
473. Fisher RD, Wang B, Alam SL, Higginson DS, Robinson H, Sundquist WI, Hill CP. 2003. Structure and ubiquitin binding of the ubiquitin-interacting motif. *J. Biol. Chem.* **278**: 28976–28984.
474. Fuglsang AT, Borch J, Bych K, Jahn TP, Roepstorff P, Palmgren MG. 2003. The binding site for regulatory 14-3-3 protein in plant plasma membrane H^+-ATPase. *J. Biol. Chem.* **278**: 42266–42272.
475. Fujino T, Sato Y, Une M, Kanayasu-Toyoda T, Yamaguchi T, Shudo K, Inoue K, Nishimaki-Mogami T. 2003. In vitro farnesoid X receptor ligand sensor assay using surface plasmon resonance and based on ligand-induced coactivator association. *J. Steroid Biochem. Mol. Biol.* **87**: 247–252.
476. Geiselhart V, Schwantes A, Bastone P, Frech M, Löchelt M. 2003. Features of the Env leader protein and the N-terminal Gag domain of feline foamy virus important for virus morphogenesis. *Virology* **310**: 235–244.
477. Glover CJ, Hite K, DeLosh R, Scudiero DA, Fivash MJ, Smith LR, Fisher RJ, Wu J-W, Shi Y, Kipp RA, McLendon GL, Sausville EA, Shoemaker RH. 2003. A high-throughput screen for identification of molecular mimics of Smac/DIABLO utilizing a fluorescence polarization assay. *Anal. Biochem.* **320**: 157–169.
478. Hamada K, Shimizu T, Yonemura S, Tsukita S, Tsukita S, Hakoshima T. 2003. Structural basis of adhesion-molecule recognition by ERM proteins revealed by the crystal structure of the radixin-ICAM-2 complex. *EMBO J.* **22**: 502–514.
479. Hanada K, Nishiuchi Y, Hirano H. 2003. Amino acid residues on the surface of soybean 4-kDa peptide involved in the interaction with its binding protein. *Eur. J. Biochem.* **270**: 2583–2592.
480. Haro I, Pérez S, García M, Chan WC, Ercilla G. 2003. Liposome entrapment and immunogenic studies of a synthetic lipophilic multiple antigenic peptide bearing VP1 and VP3 domains of the hepatitis A virus: a robust method for vaccine design. *FEBS Lett.* **540**: 133–140.
481. Heiskanen T, Li X-D, Hepojoki J, Gustafsson E, Lundkvist Å, Vaheri A, Lankinen H. 2003. Improvement of binding of Puumala virus neutralization site resembling peptide with a second-generation phage library. *Prot. Engng.* **16**: 443–450.
482. Hell K, Saleh M, Crescenzo GD, O'Connor-McCourt MD, Nicholson DW. 2003. Substrate cleavage by caspases generates protein fragments with Smac/Diablo-like activities. *Cell Death Differ.* **10**: 1234–1239.
483. Hieta R, Kukkola L, Permi P, Pirila P, Kivirikko KI, Kilpeläinen I, Myllyharju J. 2003. The peptide-substrate binding domain of human collagen prolyl 4-hydroxylases. *J. Biol Chem.* **278**: 34966–34974.
484. Hilgendorf A, Lindberg J, Ruzsics Z, Höning S, Elsing A, Löfqvist M, Engelmann H, Burgert H-G. 2003. Two distinct transport motifs in the adenovirus E3/10.4–14.5 proteins act in concert to down-modulate apoptosis receptors and the epidermal growth factor receptor. *J. Biol. Chem.* **278**: 51872–51884.
485. House CM, Frew IJ, Huang H-L, Wiche G, Traficante N, Nice E, Catimel B, Bowtell DDL. 2003. A binding motif for Siah ubiquitin ligase. *Proc. Natl. Acad. Sci USA* **100**: 3101–3106.

486. Huang L, Sexton DJ, Skogerson K, Devlin M, Smith R, Sanyal I, Parry T, Kent R, Enright J, Wu Q-l, Conley G, DeOliveira D, Morganelli L, Ducar M, Wescott CR, Ladner RC. 2003. Novel peptide inhibitors of angiotensin-converting enzyme 2. *J. Biol. Chem.* **278**: 15532–15540.
487. Hutchings NJ, Clarkson N, Chalkley R, Barclay AN, Brown MH. 2003. Linking the T cell surface protein CD2 to the actin-capping protein CAPZ via CMS and CIN85. *J. Biol. Chem.* **278**: 22396–22403.
488. Ishiwatari-Hayasaka H, Maruya M, Sreedhar AS, Nemoto TK, Csermely P, Yahara I. 2003. Interaction of neuropeptide Y and Hsp90 through a novel peptide binding region. *Biochemistry* **42**: 12972–12980.
489. Itoda K, Tamiya E, Yokoyama K. 2003. Evaluation of the molecular recognition of peptide-conjugated polymer. *Anal. Sci.* **19**: 185–187.
490. Jenke M, Sánchez A, Monje F, Stühmer W, Weseloh RM, Pardo LA. 2003. C-terminal domains implicated in the functional surface expression of potassium channels. *EMBO J.* **22**: 395–403.
491. Ji Y-H, Wang W-X, Ye J-G, He L-L, Li Y-J, Yan Y-P, Zhou Z. 2003. Martentoxin, a novel K^+-channel-blocking peptide: purification, cDNA and genomic cloning, and electrophysiological and pharmacological characterization. *J. Neurochem.* **84**: 325–335.
492. Kato Y, Ito M, Kawai K, Nagata K, Tanokura M. 2003. Determinants of ligand specificity in groups I and IV WW domains. In *Peptide Science 2002*, Yamada T (ed.). Japanese Peptide Society: Kyoto; 283–286.
493. Kirshner J, Schumann D, Shively JE. 2003. CEACAM1, a cell-cell adhesion molecule, directly associates with annexin II in a three-dimensional model of mammary morphogenesis. *J. Biol. Chem.* **278**: 50338–50345.
494. Kono K, Ueba T, Takahashi JA, Murai N, Hashimoto N, Myoumoto A, Itoh N, Fukumoto M. 2003. In vitro growth suppression of human glioma cells by a 16-mer oligopeptide: a potential new treatment modality for malignant glioma. *J. Neuro-oncol.* **63**: 163–171.
495. Kurisu G, Zakharov SD, Zhalnina MV, Bano S, Eroukova VY, Rokitskaya T, Antonenko YN, Wiener MC, Cramer WA. 2003. The structure of BtuB with bound colicin E3 R-domain implies a translocon. *Nat. Struct. Biol.* **10**: 948–954.
496. Lamla T, Erdmann VA. 2003. Searching sequence space for high-affinity binding peptides using ribosome display. *J. Mol. Biol.* **329**: 381–388.
497. Larsson M, Hjälm G, Sakwe AM, Engström Å, Höglund A-S, Larsson E, Robinson RC, Sundberg C, Rask L. 2003. Selective interaction of megalin with postsynaptic density-95 (PSD-95)-like membrane-associated guanylate kinase (MAGUK) proteins. *Biochem. J.* **373**: 381–391.
498. Lehmann U, Schmitz J, Weissenbach M, Sobota RM, Hörtner M, Friederichs K, Behrmann I, Tsiaris W, Sasaki A, Schneider-Mergener J, Yoshimura A, Neel BG, Heinrich PC, Schaper F. 2003. SHP2 and SOCS3 contribute to Tyr-759-dependent attenuation of interleukin-6 signaling through gp130. *J. Biol. Chem.* **278**: 661–671.
499. Li C, Ng MLP, Zhu Y, Ho B, Ding JL. 2003. Tandem repeats of Sushi3 peptide with enhanced LPS-binding and -neutralizing activities. *Prot. Engng.* **16**: 629–635.
500. Li P, Zhang M, Long Y-Q, Peach ML, Liu H, Yang D, Nicklaus M, Roller PP. 2003. Potent Grb2-SH2 domain antagonists not relying on phosphotyrosine mimics. *Bioorg. Med. Chem. Lett.* **13**: 2173–2177.
501. Long Y-Q, Guo R, Luo JH, Yang D, Roller PP. 2003. Potentiating effect of distant sites in non-phosphorylated cyclic peptide antagonists of the Grb2-SH2 domain. *Biochem. Biophys. Res. Commun.* **310**: 334–340.
502. Long Y-Q, Lung F-DT, Roller PP. 2003. Global optimization of conformational constraint on nonphosphorylated cyclic peptide antagonists of the Grb2-SH2 domain. *Bioorg. Med. Chem.* **11**: 3929–3936.
503. Lozzi L, Lelli B, Runci Y, Scali S, Bernini A, Falciani C, Pini A, Niccolai N, Neri P, Bracci L. 2003. Rational design and molecular diversity for the construction of anti-α-bungarotoxin antidotes with high affinity and in vivo efficiency. *Chem. Biol.* **10**: 411–417.
504. Matsumoto Y, Oda Y, Uryu M, Hayakawa Y. 2003. Insect cytokine growth-blocking peptide triggers a termination system of cellular immunity by inducing its binding protein. *J. Biol. Chem.* **278**: 38579–38585.
505. Mella M, Colotti G, Zamparelli C, Verzili D, Ilari A, Chiancone E. 2003. Information transfer in the penta-EF-hand protein Sorcin does not operate via the canonical structural/functional pairing. *J. Biol. Chem.* **278**: 24921–24928.
506. Monget P, Mazerbourg S, Delpuech T, Maurel M-C, Manière S, Zapf J, Lalmanach G, Oxvig C, Overgaard MT. 2003. Pregnancy-associated plasma protein-A is involved in insulin-like growth factor binding protein-2 (IGFBP-2) proteolytic degradation in bovine and porcine preovulatory follicles: identification of cleavage site and characterization of IGFBP-2 degradation. *Biol. Reprod.* **68**: 77–86.
507. Mousseau DD, Chapelsky S, De Crescenzo G, Kirkitadze MD, Magoon J, Inoue S, Teplow DB, O'Connor-McCourt MD. 2003. A direct interaction between TGF-βs and amyloid-β protein affects fibrillogenesis in a TGF-β receptor-independent manner. *J. Biol. Chem.* **278**: 38715–38722.
508. Mueller TD, Feigon J. 2003. Structural determinants for the binding of ubiquitin-like domains to the proteasome. *EMBO J.* **22**: 4634–4645.
509. Münk C, Wei G, Yang OO, Waring AJ, Wang W, Hong T, Lehrer RI, Landau NR, Cole AM. 2003. The θ-defensin, retrocyclin, inhibits HIV-1 entry. *AIDS Res. Hum. Retroviruses* **19**: 875–881.
510. Nakagawachi T, Soejima H, Urano T, Zhao W, Higashimoto K, Satoh Y, Matsukura S, Kudo S, Kitajima Y, Harada H, Furukawa K, Matsuzaki H, Emi M, Nakabeppu Y, Miyazaki K, Sekiguchi M, Mukai T. 2003. Silencing effect of CpG island hypermethylation and histone modification on O6-methylguanine-DNA methyltransferase (*MGMT*) gene expression in human cancer. *Oncogene* **22**: 8835–8844.
511. Noinville S, Bruston F, El Amri C, Baron D, Nicholas P. 2003. Conformation, orientation, and adsorption kinetics of dermaseptin B2 onto synthetic supports at aqueous/solid interface. *Biophys. J.* **85**: 1196–1206.
512. Oishi T, Hagiwara K-I, Kinumi T, Yamakawa Y, Nishijima M, Nakamura K, Arimoto H. 2003. Effects of β-sheet breaker peptide polymers on scrapie-infected mouse neuroblastoma cells and their affinities to prion protein fragment PrP(81–145). *Org. Biomol. Chem.* **1**: 2626–2629.
513. Ojennus DD, Lehto SE, Wuttke DS. 2003. Electrostatic interactions in the reconstitution of an SH2 domain from constituent peptide fragments. *Prot. Sci.* **12**: 44–55.
514. Oomen CJ, Hoogerhout P, Bonvin AMJJ, Kuipers B, Brugghe H, Timmermans H, Haseley SR, van Alphen L, Gros P. 2003. Immunogenicity of peptide-vaccine candidates predicted by molecular dynamics simulations. *J. Mol. Biol.* **328**: 1083–1089.
515. Pantarotto D, Partidos CD, Hoebeke J, Brown F, Kramer E, Briand J-P, Muller S, Prato M, Bianco A. 2003. Immunization with peptide-functionalized carbon nanotubes enhances virus-specific neutralizing antibody responses. *Chem. Biol.* **10**: 961–966.
516. Peter J-C, Eftekhari P, Billiald P, Wallukat G, Hoebeke J. 2003. scFv single chain antibody variable fragment as inverse agonist of the β_2-adrenergic receptor. *J. Biol. Chem.* **278**: 36740–36747.
517. Petoral JRM, Herland A, Broo K, Uvdal K. 2003. G-protein interactions with receptor-derived peptides chemisorbed on gold. *Langmuir* **19**: 10304–10309.
518. Pornillos O, Higginson DS, Stray KM, Fisher RD, Garrus JE, Payne M, He G-P, Wang HE, Morham SG, Sundquist WI. 2003. HIV Gag mimics the Tsg101-recruiting activity of the human Hrs protein. *J. Cell Biol.* **162**: 425–434.
519. Pütz MM, Hoebeke J, Ammerlaan W, Schneider S, Muller CP. 2003. Functional fine-mapping and molecular modeling of a conserved loop epitope of the measles virus hemagglutinin protein. *Eur. J. Biochem.* **270**: 1515–1527.
520. Qin D, Lee H, Yuan C, Ju Y, Tsai M-D. 2003. Identification of potential binding sites for the FHA domain of human Chk2 by *in vitro* binding studies. *Biochem. Biophys. Res. Commun.* **311**: 803–808.

521. Raffler NA, Schneider-Mergener J, Famulok M. 2003. A novel class of small functional peptides that bind and inhibit human α-thrombin isolated by mRNA display. *Chem. Biol.* **10**: 69–79.
522. Ryadnov MG, Ceyhan B, Niemeyer CM, Woolfson DN. 2003. 'Belt and braces': a peptide-based linker system of de novo design. *J. Am. Chem. Soc.* **125**: 9388–9394.
523. Sahu A, Morikis D, Lambris JD. 2003. Compstatin, a peptide inhibitor of complement, exhibits species-specific binding to complement component C3. *Mol. Immunol.* **39**: 557–566.
524. Scalley-Kim M, Minard P, Baker D. 2003. Low free energy cost of very long loop insertions in proteins. *Prot. Sci.* **12**: 197–206.
525. Soulika AM, Morikis D, Sarrias M-R, Roy M, Spruce LA, Sahu A, Lambris JD. 2003. Studies of structure-activity relations of complement inhibitor compstatin. *J. Immunol.* **170**: 1881–1890.
526. Su J-L, Ao Z, Aiyar NV, Ellis B, Martin JD, Douglas SA, Kull Jr FC. 2003. Production and characterization of monoclonal antibodies against the vasoconstrictive peptide human urotensin-II. *Hybrid Hybridomics* **22**: 377–382.
527. Suenaga A, Hatakeyama M, Ichikawa M, Yu X, Futatsugi N, Narumi T, Fukui K, Terada T, Taiji M, Shirouzu M, Yokoyama S, Konagaya A. 2003. Molecular dynamics, free energy, and SPR analyses of the interactions between the SH2 domain of Grb2 and ErbB phosphotyrosyl peptides. *Biochemistry* **42**: 5195–5200.
528. Sweeney SM, DiLullo G, Slater SJ, Martinez J, Iozzo RV, Lauer-Fields JL, Fields GB, San Antonio JD. 2003. Angiogenesis in collagen I requires $\alpha_2\beta_1$ ligation of a GFP*GER sequence and possibly p38 MAPK activation and focal adhesion disassembly. *J. Biol. Chem.* **278**: 30516–30524.
529. Tamm I, Trepel M, Cardó-Vila M, Sun Y, Welsh K, Cabezas E, Swatterthwait A, Arap W, Reed JC, Pasqualini R. 2003. Peptides targeting caspase inhibitors. *J. Biol. Chem.* **278**: 14401–14405.
530. Tani F, Shirai N, Nakanishi Y, Kitabatake N. 2003. Analysis of molecular interactions in heat-induced aggregation of a non-inhibitory serpin ovalbumin using a molecular chaperone. *Biosci. Biotechnol. Biochem.* **67**: 1030–1038.
531. Tripet B, De Crescenzo G, Grothe S, O'Connor-McCourt M, Hodges RS. 2003. Kinetic analysis of the interactions between troponin C (TnC) and troponin I (TnI) binding peptides: evidence for separate binding sites for the structural N-terminus and the regulatory C-terminus of TnI on TnC. *J. Mol. Recognit.* **16**: 37–53.
532. Tsurumi Y, Hayakawa M, Shibata Y, Abiko Y. 2003. Production of antibody against a synthetic peptide of *Porphyromonas gingivalis* 40-kDa outer membrane protein. *J. Oral Sci.* **45**: 111–116.
533. von Schwedler UK, Stuchell M, Müller B, Ward DM, Chung H-Y, Morita E, Wang HE, Davis T, He G-P, Cimbora DM, Scott A, Kräusslich H-G, Kaplan J, Morham SG, Sundquist WI. 2003. The protein network of HIV budding. *Cell* **114**: 701–713.
534. Wiederkehr-Adam M, Ernst P, Muller K, Bieck E, Gombert FO, Ottl J, Graff P, Grossmüller F, Heim MH. 2003. Characterization of phosphopeptide motifs specific for the Src homology 2 (SH2) domains of signal transducer and activator of transcription 1 (STAT1) and STAT3. *J. Biol. Chem.* **278**: 16117–16128.
535. Wilson-Annan J, O'Reilly LA, Crawford SA, Hausmann G, Beaumont JG, Parma LP, Chen L, Lackmann M, Lithgow T, Hinds MG, Day CL, Adams JM, Huang DCS. 2003. Proapoptotic BH3-only proteins trigger membrane integration of prosurvival Bcl-w and neutralize its activity. *J. Cell. Biol.* **162**: 877–887.
536. Won J, Hur Y-G, Hur EM, Park S-H, Kang M-A, Choi Y, Park C, Lee K-H, Yun Y. 2003. Rosmarinic acid inhibits TCR-induced T cell activation and proliferation in an Lck-dependent manner. *Eur. J. Immunol.* **33**: 870–879.
537. Xu K, Belunis C, Chu W, Weber D, Podlaski F, Huang K-S, Reed SI, Vassilev LT. 2003. Protein-protein interactions involved in the recognition of p27 by E3 ubiquitin ligase. *Biochem. J.* **371**: 957–964.
538. Yamamoto N, Sakai F, Kon S, Morimoto J, Kimura C, Yamazaki H, Okazaki I, Seki N, Fujii T, Uede T. 2003. Essential role the cryptic epitope SLAYGLR within osteopontin in a murine model of rheumatoid arthritis. *J. Clin. Invest.* **112**: 181–188.
539. Yoburn JC, Deb S, Manfield IW, Stockley PG, Van Vranken DL. 2003. A blaryl peptide crosslink in a MetJ peptide model confers cooperative, nonspecific binding to DNA that ablates both repressor binding and in vitro transcription. *Bioorg. Med. Chem.* **11**: 811–816.
540. Yonezawa M, Doi N, Kawahashi Y, Higashinakagawa T, Yanagawa H. 2003. DNA display for *in vitro* selection of diverse peptide libraries. *Nucl. Acids Res.* **31**: e118.
541. Young PJ, Francis JW, Lince D, Coon K, Androphy EJ, Lorson CL. 2003. The Ewing's sarcoma protein interacts with the Tudor domain of the survival motor neuron protein. *Mol. Brain Res.* **119**: 37–49.
542. Yribarren AS, Thomas D, Friboulet A, Avalle B. 2003. Selection of peptides inhibiting a β-lactamase-like activity. *Eur. J. Biochem.* **270**: 2789–2795.
543. Yu X, Chini CCS, He M, Mer G, Chen J. 2003. The BRCT domain is a phospho-protein binding domain. *Science* **302**: 639–642.
544. Zander K, Sherman MP, Tessmer U, Bruns K, Wray V, Prechtel AT, Schubert E, Henklein P, Luban J, Neidleman J, Greene WC, Schubert U. 2003. Cyclophilin A interacts with HIV-1 Vpr and is required for its functional expression. *J. Biol. Chem.* **278**: 43202–43213.
545. Zimmermann J, Kuhne R, Volkmer-Engert R, Jarchau T, Walter U, Oschkinat H, Ball LJ. 2003. Design of N-substituted peptomer ligands for EVH1 domains. *J. Biol. Chem.* **278**: 36810–36818.

Oligonucleotides.

546. Airenne TT, Torkko JM, Van den plas S, Sormunen RT, Kastaniotis AJ, Wierenga RK, Hiltunen JK. 2003. Structure-function analysis of enoyl thioester reductase involved in mitochondrial maintenance. *J. Mol. Biol.* **327**: 47–59.
547. Akao Y, Yoshida H, Matsumoto K, Matsui T, Hogetu K, Tanaka N, Usukura J. 2003. A tumor-associated DEAD-box protein, rck/p54 exhibits RNA unwinding activity toward c-myc RNAs *in vitro*. *Genes Cells* **8**: 671–676.
548. Aoyama Y, Kanamori T, Nakai T, Sasaki T, Horiuchi S, Sando S, Niidome T. 2003. Artificial viruses and their application to gene delivery. Size-controlled gene coating with glycocluster nanoparticles. *J. Am. Chem. Soc.* **125**: 3455–3457.
549. Asai R, Nakamura C, Ikebukuro K, Karube I, Miyake J. 2003. A bioassay to detect contaminant-induced messenger RNA using a transcriptomic approach: detection of RT-PCR-amplified single-stranded DNA based on the SPR sensor in cyanobacteria. *Anal. Lett.* **36**: 1475–1491.
550. Asai R, Nakanishi K, Nakamura C, Ikebukuro K, Miyake J, Karube I. 2003. A polymerase chain reaction-based ribosomal DNA detection technique using a surface plasmon resonance detector for a red tide causing micoalga, *Alexandrium affine*. *Phycol. Res.* **51**: 118–125.
551. Asai R, Ootani K, Nomura Y, Nakamura C, Ikebukuro K, Arikawa Y, Miyake J, Karube I. 2003. PCR-based ribosomal DNA detection technique for microalga *(Heterosigma carterae)* causing red tide and its application to a biosensor using labeled probe. *Mar. Biotechnol.* **5**: 417–423.
552. Bailly C, Carrasco C, Joubert A, Bal C, Wattez N, Hildebrand M-P, Lansiaux A, Colson P, Houssier C, Cacho M, Ramos A, Braña MF. 2003. Chromophoremodified bisnaphthalimides: DNA recognition, topoisomerase inhibition, and cytotoxic properties of two mono- and bisfuronaphthalimides. *Biochemistry* **42**: 4136–4150.
553. Bailly C, Chessari G, Carrasco C, Joubert A, Mann J, Wilson WD, Neidle S. 2003. Sequence-specific minor groove binding by *bis*-benzimidazoles: water molecules in ligand recognition. *Nucl. Acids Res.* **31**: 1514–1524.
554. Baitinger C, Burdett V, Modrich P. 2003. Hydrolytically deficient MutS E694A is defective in the MutL-dependent activation of MutH and in the mismatch-dependent assembly of the MutS·MutL·heteroduplex complex. *J. Biol. Chem.* **278**: 49505–49511.
555. Berger I, Bieniossek C, Schaffitzel C, Hassler M, Santelli E, Richmond TJ. 2003. Direct interaction of Ca^{2+}/calmodulin inhibits histone deacetylase 5 repressor core binding to myocyte enhancer factor 2. *J. Biol. Chem.* **278**: 17625–17635.
556. Bheemanaik S, Chandrashekaran S, Nagaraja V, Rao DN. 2003. Kinetic and catalytic properties of dimeric *KpnI* DNA methyltransferase. *J. Biol. Chem.* **278**: 7863–7874.

557. Biet E, Sun J-S, Dutreix M. 2003. Stimulation of D-loop formation by polypurine/polypyrimidine sequences. *Nucl. Acids Res.* **31**: 1006–1012.
558. Binz SK, Lao Y, Lowry DF, Wold MS. 2003. The phosphorylation domain of the 32-kDa subunit of replication protein A (RPA) modulates RPA-DNA interactions. *J. Biol. Chem.* **278**: 35584–35591.
559. Bjornson KP, Blackwell LJ, Sage H, Baitinger C, Allen D, Modrich P. 2003. Assembly and molecular activities of the MutS tetramer. *J. Biol. Chem.* **278**: 34667–34673.
560. Brekasis D, Paget MSB. 2003. A novel sensor of NADH/NAD$^+$ redox poise in *Streptomyces coelicolor* A3(2). *EMBO J.* **22**: 4856–4865.
561. Carlson CB, Vuyisich M, Gooch BD, Beal PA. 2003. Preferred RNA binding sites for a threading intercalator revealed by in vitro evolution. *Chem. Biol.* **10**: 663–672.
562. Chan AY, Lim BL. 2003. Interaction of a putative transcriptional regulatory protein and the thermo-inducible cts-52 mutant repressor in the *Bacillus subtilis* phage ϕ105 genome. *J. Mol. Biol.* **333**: 21–31.
563. Cheong H-K, Park J-Y, Kim E-H, Lee C, Kim S, Kim Y, Choi B-S, Cheong C. 2003. Structure of the N-terminal extension of human aspartyl-tRNA synthetase: implications for its biological function. *Int. J. Biochem. Cell Biol.* **35**: 1548–1557.
564. Christ D, Winter G. 2003. Identification of functional similarities between proteins using directed evolution. *Proc. Natl. Acad. Sci. USA* **100**: 13202–13206.
565. Cieslak M, Szymanski J, Adamiak RW, Cierniewski CS. 2003. Structural rearrangements of the 10–23 DNAzyme to β3 integrin subunit mRNA induced by cations and their relations to the catalytic activity. *J. Biol. Chem.* **278**: 47987–47996.
566. Classen S, Lyons D, Cech TR, Schultz SC. 2003. Sequence-specific and 3′-end selective single-strand DNA binding by the *Oxytricha nova* telomere end binding protein α subunit. *Biochemistry* **42**: 9269–9277.
567. Daniels DA, Chen H, Hicke BJ, Swiderek KM, Gold L. 2003. A tenascin-C aptamer identified by tumor cell SELEX: systematic evolution of ligands by exponential enrichment. *Proc. Natl. Acad. Sci. USA* **100**: 15416–15421.
568. Delagoutte E, von Hippel PH. 2003. Function and assembly of the bacteriophage T4 DNA replication complex. *J. Biol. Chem.* **278**: 25435–25447.
569. Evans-Galea MV, Blankman E, Myszka DG, Bird AJ, Eide DJ, Winge DR. 2003. Two of the five zinc fingers in the Zap1 transcription factor DNA binding domain dominate site-specific DNA binding. *Biochemistry* **42**: 1053–1061.
570. Finucane MD, Jardetzky O. 2003. Surface plasmon resonance studies of wild-type and AV77 tryptophan repressor resolve ambiguities in super-repressor activity. *Prot. Sci.* **12**: 1613–1620.
571. Fourrier L, Brooks P, Malinge J-M. 2003. Binding discrimination of MutS to a set of lesions and compound lesions (base damage and mismatch) reveals its potential role as a cisplatin-damaged DNA sensing protein. *J. Biol. Chem.* **278**: 21267–21275.
572. Fukuda N, Furuya R, Kishioka H, Suzuki R, Matsuda H, Tahira Y, Takagi H, Ikeda Y, Saito S, Matsumoto K, Kanmatsuse K. 2003. Effects of antisense peptide nucleic acid to platelet-derived growth factor A-chain on growth of vascular smooth muscle cells. *J. Cardovasc. Pharmac.* **42**: 224–231.
573. Fukumori T, Morita Y, Tamiya E, Yokoyama K. 2003. Design of peptide that recognizes double-stranded DNA. *Anal. Sci.* **19**: 181–183.
574. Gallego J, Greatorex J, Zhang H, Yang B, Arunachalam S, Fang J, Seamons J, Lea S, Pomerantz R, Lever AML. 2003. Rev binds specifically to a purine loop in the SL1 region of the HIV-1 leader RNA. *J. Biol. Chem.* **278**: 40385–40391.
575. Giakoumaki E, Minunni M, Tombelli S, Tothill IE, Mascini M, Bogani P, Buiatti M. 2003. Combination of amplification and post-amplification strategies to improve optical DNA sensing. *Biosens. Bioelectron.* **19**: 337–344.
576. Göringer HU, Homann M, Lorger M. 2003. In vitro selection of high-affinity nucleic acid ligands to parasite target molecules. *Int. J. Parasit.* **33**: 1309–1317.
577. Grinberg AV, Kerppola TK. 2003. Both Max and TFE3 cooperate with Smad proteins to bind the PAI-1 promoter, but they have opposite effects on transcriptional activity. *J. Biol. Chem.* **278**: 11227–11236.
578. Grúz P, Shimizu M, Pisani FM, De Felice M, Kanke Y, Nohmi T. 2003. Processing of DNA lesions by archaeal DNA polymerases from *Sulfolobus solfataricus*. *Nucl. Acids Res.* **31**: 4024–4030.
579. Gu B, Johnston VK, Gutshall LL, Nguyen TT, Gontarek RR, Darcy MG, Tedesco R, Dhanak D, Duffy KJ, Kao CC, Sarisky RT. 2003. Arresting initiation of HCV RNA synthesis using heterocyclic derivatives. *J. Biol. Chem.* **278**: 16602–16607.
580. Hao D, Ohme-Takagi M, Yamasaki K. 2003. A modified sensor chip for surface plasmon resonance enables a rapid determination of sequence specificity of DNA-binding proteins. *FEBS Lett.* **536**: 151–156.
581. He J, Liu G, Zhang S, Vanderheyden J-L, Liu N, Liu C, Zhang Y, Gupta S, Rusckowski M, Hnatowich DJ. 2003. A comparison of *in vitro* and *in vivo* stability in mice of two morpholino duplexes differing in chain length. *Bioconjug. Chem.* **14**: 1018–1023.
582. He Z-G, Rezende LF, Willcox S, Griffith JD, Richardson CC. 2003. The carboxyl-terminal domain of bacteriophage T7 single-stranded DNA-binding protein modulates DNA binding and interaction with T7 DNA polymerase. *J. Biol. Chem.* **278**: 29538–29545.
583. Heldt C, Listing J, Sözeri O, Bläsing F, Frischbutter S, Müller B. 2003. Differential expression of HLA class II genes associated with disease susceptibility and progression in rheumatoid arthritis. *Arthritis Rheum.* **48**: 2779–2787.
584. Hickman DT, Tan THS, Morral J, King PM, Cooper MA, Micklefield J. 2003. Design, synthesis, conformational analysis and nucleic acid hybridisation properties of thymidyl pyrrolidine-amide oligonucleotide mimics (POM). *Org. Biomol. Chem.* **1**: 3277–3292.
585. Hoffrogge R, Mikschofsky H, Piechulla B. 2003. Surface plasmon resonance spectroscopy (SPR) interaction studies of the circadian-controlled tomato LHCa4*1 (CAB 11) protein with its promoter. *Chronobiol. Int.* **20**: 543–558.
586. Jahn-Hofmann K, Holzhey N, Ellinger T, Engles JW. 2003. A new concept for DNA-arrays. *Nucleoside Nucleotide Nucl. Acids* **22**: 1479–1482.
587. Jensen LH, Renodon-Cornière A, Nitiss KC, Hill BT, Nitiss JL, Jensen PB, Sehested M. 2003. A dual mechanism of action of the anticancer agent F 11782 on human topoisomerase II α. *Biochem. Pharmac.* **66**: 623–631.
588. Jiang Y, Pacek M, Helinski DR, Konieczny I, Toukdarian A. 2003. A multifunctional plasmid-encoded replication initiation protein both recruits and positions an active helicase at the replication origin. *Proc. Natl. Acad. Sci. USA* **100**: 8692–8697.
589. Khati M, Schüman M, Ibrahim J, Sattentau Q, Gordon S, James W. 2003. Neutralization of infectivity of diverse R5 clinical isolates of human immunodeficiency virus type 1 by gp120-binding 2′F-RNA aptamers. *J. Virol.* **77**: 12692–12698.
590. Kikuchi K, Umehara T, Fukuda K, Hwang J, Kuno A, Hasegawa T, Nishikawa S. 2003. RNA aptamers targeted to domain II of hepatitis C virus IRES that bind to its apical loop region. *J. Biochem.* **133**: 263–270.
591. Kikuchi K, Umehara T, Fukuda K, Hwang J, Kuno A, Hasegawa T, Nishikawa S. 2003. Structure-inhibition analysis of RNA aptamers that bind to HCV IRES. *Nucl. Acids Res. Suppl.* **3**: 291–292.
592. Kim E, Kim K, Yang H, Kim YT, Kwak J. 2003. Enzyme-amplified electrochemical detection of DNA using electrocatalysis of ferrocenyl-tethered dendrimer. *Anal. Chem.* **75**: 5665–5672.
593. Kim MY, Jeong S. 2003. RNA aptamers that bind the nucleocapsid protein contain pseudoknots. *Mol. Cells* **16**: 413–417.
594. Kim Y-M, Choi KH, Jang Y-J, Yu J, Jeong S. 2003. Specific modulation of the anti-DNA autoantibody-nucleic acids interaction by the high affinity RNA aptamer. *Biochem. Biophys. Res. Commun.* **300**: 516–523.
595. Kostelac D, Rechkemmer G, Briviba K. 2003. Phytoestrogens modulate binding response of estrogen receptors α and β to the estrogen response element. *J. Agric. Food Chem.* **51**: 7632–7635.

596. Larsson C, Rodahl M, Hook F. 2003. Characterization of DNA immobilization and subsequent hybridization on a 2D arrangement of streptavidin on a biotin-modified lipid bilayer supported on SiO_2. *Anal. Chem.* **75**: 5080–5087.
597. Leontiou C, Lightowlers R, Lakey JH, Austin CA. 2003. Kinetic analysis of human topoisomerase IIα and β DNA binding by surface plasmon resonance. *FEBS Lett.* **554**: 206–210.
598. Leppard JB, Dong Z, Mackey ZB, Tomkinson AE. 2003. Physical and functional interaction between DNA ligase IIIβ and poly(ADP-ribose) polymerase 1 in DNA single-strand break repair. *Mol. Cell. Biol.* **23**: 5919–5927.
599. Lau FP, Georgescu R, O'Donnell M. 2003. Mechanism of the *E. coli* τ processivity switch during lagging-strand synthesis. *Mol. Cell* **11**: 315–327.
600. Li ZL, Abe H, Ueki K, Kumagai K, Araki R, Otsuki Y. 2003. Identification of c-Jun as bcl-2 transcription factor in human uterine endometrium. *J. Histochem. Cytochem.* **51**: 1601–1609.
601. Lin Q, Barbas III CF, Schultz PG. 2003. Small-molecule switches for zinc finger transcription factors. *J. Am. Chem. Soc.* **125**: 612–613.
602. Lionneton F, Lelievre E, Baillat D, Stehelin D, Soncin F. 2003. Characterization and functional analysis of the p42Ets-1 variant of the mouse Ets-1 transcription factor. *Oncogene* **12**: 9156–9164.
603. Maesawa C, Inaba T, Sato H, Iijima S, Ishida K, Terashima M, Sato R, Suzuki M, Yashima A, Ogasawara S, Oikawa H, Sato N, Saito K, Masuda T. 2003. A rapid biosensor chip assay for measuring of telomerase activity using surface plasmon resonance. *Nucl. Acids Res.* **31**: e4.
604. Majka J, Burgers PMJ. 2003. Yeast Rad17/Mec3/Ddc1: a sliding clamp for the DNA damage checkpoint. *Proc. Natl. Acad. Sci. USA* **100**: 2249–2254.
605. Matsui E, Nishio M, Yokoyama H, Harata K, Darnis S, Matsui I. 2003. Distinct domain fuctions regulating de novo DNA synthesis of thermostable DNA primase from hyperthermophile *Pyrococcus horikoshii*. *Biochemistry* **42**: 14968–14976.
606. Mayer C, Köhrer C, Kenny E, Prusko C, RajBhandary UL. 2003. Anticodon sequence mutants of *Escherichia coli* initiator tRNA: effects of overproduction of aminoacyl-tRNA synthetases, methionyl-tRNA formyltransferase, and initiation factor 2 on activity in initiation. *Biochemistry* **42**: 4787–4799.
607. McGregor A, Smith PM, Ross GF, Taylor RW, Turnbull DM, Lightowlers RN. 2003. Bridging PNAs can bind preferentially to a deleted mitochondrial DNA template but replication by mitochondrial DNA polymerase γ in vitro is not impaired. *Biochim. Biophys. Acta* **1629**: 73–83.
608. McKercher SR, Lombardo CR, Bobkov A, Jia X, Assa-Munt N. 2003. Identification of a PU.1-IRF4 protein interaction surface predicted by chemical exchange line broadening. *Proc. Natl. Acad. Sci. USA* **100**: 511–516.
609. Mizukoshi T, Tanaka T, Arai K-i, Kohda D, Masai H. 2003. A critical role of the 3′ terminus of nascent DNA chains in recognition of stalled replication forks. *J. Biol. Chem.* **278**: 42234–42239.
610. Møller-Jensen J, Borch J, Dam M, Jensen RB, Roepstorff P, Gerdes K. 2003. Bacterial mitosis: ParM of plasmid R1 moves plasmid DNA by an actin-like insertional polymerization mechanism. *Mol. Cell* **12**: 1477–1487.
611. Morin A, Huysveld N, Braun F, Dimova D, Sakanyan V, Charlier D. 2003. Hyperthermophilic *Thermotoga* arginine repressor binding to full-length cognate and heterologous arginine operators and to half-site targets. *J. Mol. Biol.* **332**: 537–553.
612. Mühlberger R, Robelek R, Eisenreich W, Ettenhuber C, Sinner EK, Kessler H, Bacher A, Richter G. 2003. RNA DNA discrimination by the antitermination protein NusB. *J. Mol. Biol.* **327**: 973–983.
613. Murphy MB, Fuller ST, Richardson PM, Doyle SA. 2003. An improved method for the *in vitro* evolution of aptamers and applications in protein detection and purification. *Nucl. Acids Res.* **31**: e110.
614. Nakatani K, Hagihara S, Sando S, Sakamoto S, Yamaguchi K, Maesawa C, Saito I. 2003. Induction of a remarkable conformational change in a human telomeric sequence by the binding of naphthyridine dimer: inhibition of the elongation of a telomeric repeat by telomerase. *J. Am. Chem. Soc.* **125**: 662–666.
615. Nomura W, Sugiura Y. 2003. Effects of length and position of an extended linker on sequence-selective DNA recognition of zinc finger peptides. *Biochemistry* **42**: 14805–14813.
616. Oguro A, Ohtsu T, Svitkin YV, Sonenberg N, Nakamura Y. 2003. RNA aptamers to initiation factor 4A helicase hinder cap-dependent translation by blocking ATP hydrolysis. *RNA* **9**: 394–407.
617. Okumoto Y, Tanabe Y, Sugimoto N. 2003. Factors that contribute to efficient catalytic activity of a small Ca^{2+}-dependent deoxyribozyme in relation to its RNA cleavage function. *Biochemistry* **42**: 2158–2165.
618. Palaniyar N, Nadesalingam J, Reid KBM. 2003. Innate immune collectins bind nucleic acids and enhance DNA clearance *in vitro*. *Ann. NY Acad. Sci.* **1010**: 467–470.
619. Park-Lee S, Kim S, Laird-Offringa IA. 2003. Characterization of the interaction between neuronal RNA-binding protein HuD and AU-rich RNA. *J. Biol. Chem.* **278**: 39801–39808.
620. Pileur F, Andreola M-L, Dausse E, Michel J, Moreau S, Yamada H, Gaidamakov SA, Crouch RJ, Toulmé J-J, Cazenave C. 2003. Selective inhibitory DNA aptamers of the human RNase H1. *Nucl. Acids Res.* **31**: 5776–5788.
621. Pristovšek P, Sengupta K, Löhr F, Schäfer B, Wehland Von Trebra M, Rüterjans H, Bernhard F. 2003. Structural analysis of the DNA-binding domain of the *Erwinia amylovora* RcsB protein and its interaction with the RcsAB box. *J. Biol. Chem.* **278**: 17752–17759.
622. Purschke WG, Radtke F, Kleinjung F, Klussmann S. 2003. A DNA Spiegelmer to staphylococcal enterotoxin B. *Nucl. Acids Res.* **31**: 3027–3032.
623. Rajendran KS, Nagy PD. 2003. Characterization of the RNA-binding domains in the replicase proteins of tomato bushy stunt virus. *J. Virol.* **77**: 9244–9258.
624. Renodon-Cornière A, Sørensen TK, Jensen PB, Nitiss JL, Søkilde B, Sehested M, Jensen LH. 2003. Probing the role of linker substituents in bisdioxopiperazine analogs for activity against wild-type and mutant human topoisomerase IIα. *Mol. Pharmac.* **63**: 1159–1168.
625. Sadana A. 2003. A fractal analysis of protein to DNA binding kinetics using biosensors. *Biosens. Bioelectron.* **18**: 985–997.
626. Saïda F, Uzan M, Bontems F. 2003. The phage T4 restriction endoribonuclease RegB: a cyclizing enzyme that requires two histidines to be fully active. *Nucl. Acids Res.* **31**: 2751–2758.
627. Sato Y, Fujimoto K, Kawaguchi H. 2003. Detection of a K-*ras* point mutation employing peptide nucleic acid at the surface of a SPR biosensor. *Colloids Surf. B* **27**: 23–31.
628. Sato Y, Ikegaki S, Suzuki K, Kawaguchi H. 2003. Hydrogel-microsphere-enhanced surface plasmon resonance for the detection of a K-*ras* point mutation employing peptide nucleic acid. *J. Biomater. Sci.* **14**: 803–820.
629. Sazani P, Astriab-Fischer A, Kole R. 2003. Effects of base modifications on antisense properties of 2′-O-methoxyethyl and PNA oligonucleotides. *Antisense Nucl. Acid Drug Dev.* **13**: 119–128.
630. Schaufler LE, Klevit RE. 2003. Mechanism of DNA binding by the ADR1 zinc finger transcription factor as determined by SPR. *J. Mol. Biol.* **329**: 931–939.
631. Schouten JA, Ladame S, Mason SJ, Cooper MA, Balasubramanian S. 2003. G-quadruplex-specific peptide-hemicyanine ligands by partial combinatorial selection. *J. Am. Chem. Soc.* **125**: 5594–5595.
632. Schubert F, Zettl H, Häfner W, Krauss G, Krausch G. 2003. Comparative thermodynamic analysis of DNAprotein interactions using surface plasmon resonance and fluorescence correlation spectroscopy. *Biochemistry* **42**: 10288–10294.
633. Spiering MM, Ringe D, Murphy JR, Marletta MA. 2003. Metal stoichiometry and functional studies of the diphtheria toxin repressor. *Proc. Natl. Acad. Sci. USA* **100**: 3808–3813.
634. Taira S, Morita Y, Tamiya E, Yokoyama K. 2003. Selfassembled DNA-conjugated polymer for novel DNA chip. *Anal. Sci.* **19**: 177–179.
635. Tamura M, Nashimoto C, Miyake N, Daikuhara Y, Ochi K, Nashimoto M. 2003. Intracellular mRNA cleavage by 3′ tRNase under the direction of 2′-O-methyl RNA heptamers. *Nucl. Acids Res.* **31**: 4354–4360.

636. Teulade-Fichou M-P, Carrasco C, Guittat L, Bailly C, Alberti P, Mergny J-L, David A, Lehn JM, Wilson WD. 2003. Selective recognition of G-quadruplex telomeric DNA by a bis(quinacridine) macrocycle. *J. Am. Chem. Soc.* **125**: 4732–4740.
637. Teulade-Fichou M-P, Hounsou C, Guittat L, Mergny J-L, Alberti P, Carrasco C, Bailly C, Lehn JM, Wilson WD. 2003. Molecular recognition of quadruplex DNA by quinacridine derivatives. *Nucleoside Nucleotide Nucl. Acids* **22**: 1483–1485.
638. Tran TT, Reich III CF, Alam M, Pisetsky DS. 2003. Specificity and immunochemical properties of anti-DNA antibodies induced in normal mice by immunization with mammalian DNA with a CpG oligonucleotide as adjuvant. *Clin. Immunol.* **109**: 278–287.
639. Tsoi PY, Zhang X, Sui S-f, Yang M. 2003. Effects of DNA mismatches on binding affinity and kinetics of polymerase-DNA complexes as revealed by surface plasmon resonance biosensor. *Analyst* **128**: 1169–1174.
640. Vickerman MM, Wang M, Baker LJ. 2003. An amino acid change near the carboxyl terminus of the *Streptococcus gordonii* regulatory protein Rgg affects its abilities to bind DNA and influence expression of the glucosyltransferase gene gtfG. *Microbiology* **149**: 399–406.
641. Volkov A, Mascarenhas J, Andrei-Selmer C, Ulrich HD, Graumann PL. 2003. A prokaryotic condensin/cohesinlike complex can actively compact chromosomes from a single position on the nucleoid and binds to DNA as a ring-like structure. *Mol. Cell. Biol.* **23**: 5638–5650.
642. Yang W, Xu Y, Wu J, Zheng W, Shi Y. 2003. Solution structure and DNA binding property of the fifth HMG box domain in comparison with the first HMG box domain in human upstream binding factor. *Biochemistry* **42**: 1930–1938.
643. You J-S, Wang M, Lee S-H. 2003. Biochemical analysis of the damage recognition process in nucleotide excision repair. *J. Biol. Chem.* **278**: 7476–7485.
644. Zawilak A, Durrant MC, Jakimowicz P, Backert S, Zakrzewska-Czerwińska J. 2003. DNA binding specificity of the replication initiator protein, DnaA from *Helicobacter pylori*. *J. Mol. Biol.* **334**: 933–947.
645. Zhang W, Wu Q, Pwee K-H, Jois SDS, Kini RM. 2003. Characterization of the interaction of wheat HMGa with linear and four-way junction DNAs. *Biochemistry* **42**: 6596–6607.

Lipids and self-assembled monolayers.

646. Ananthanarayanan B, Stahelin RV, Digman MA, Cho W. 2003. Activation mechanisms of conventional protein kinase C isoforms are determined by the ligand affinity and conformational flexibility of their C1 Domains. *J. Biol. Chem.* **278**: 46886–46894.
647. Borthakur G, Cruz MA, Dong JF, McIntire L, Li F, López JA, Thiagarajan P. 2003. Sulfatides inhibit platelet adhesion to von Willebrand factor in flowing blood. *J. Thromb. Haemost.* **1**: 1288–1295.
648. Cantu III C, Benlagha K, Savage PB, Bendelac A, Teyton L. 2003. The paradox of immune molecular recognition of α-galactosylceramide: low affinity, low specificity for CD1d, high affinity for $\alpha\beta$ TCRs. *J. Immunol.* **170**: 4673–4682.
649. Chen HM, Leung KW, Thakur NN, Tan A, Jack RW. 2003. Distinguishing between different pathways of bilayer disruption by the related antimicrobial peptides cecropin B, B1 and B3. *Eur. J. Biochem.* **270**: 911–920.
650. Critchley P, Willand MN, Rullay AK, Crout DHG. 2003. Carbohydrate-protein interactions at interfaces: synthesis of thiolactosyl glycolipids and design of a working model for surface plasmon resonance. *Org. Biomol. Chem.* **1**: 928–938.
651. Critchley P, Clarkson GJ. 2003. Carbohydrate-protein interactions at interfaces: comparison of the binding of Ricinus communis lectin to two series of synthetic glycolipids using surface plasmon resonance studies. *Org. Biomol. Chem.* **1**: 4148–4159.
652. Das S, Dixon JE, Cho W. 2003. Membrane-binding and activation mechanism of PTEN. *Proc. Natl. Acad. Sci. USA* **100**: 7491–7496.
653. Das S, Rafter JD, Kim KP, Gygi SP, Cho W. 2003. Mechanism of group IVA cytosolic phospholipase A_2 activation by phosphorylation. *J. Biol. Chem.* **278**: 41431–41442.
654. De Haro L, Quetglas S, Iborra C, Lévêque C, Seagar M. 2003. Calmodulin-dependent regulation of a lipid binding domain in the v-SNARE synaptobrevin and its role in vesicular fusion. *Biol. Cell* **95**: 459–464.
655. de Keyzer J, van der Does C, Kloosterman TG, Driesson AJM. 2003. Direct demonstration of ATP-dependent release of SecA from a translocating preprotein by surface plasmon resonance. *J. Biol. Chem.* **278**: 29581–29586.
656. Frederix F, Bonroy K, Laureyn W, Reekmans G, Campitelli A, Dehaen W, Maes G. 2003. Enchanced performance of an affinity biosensor interface based on mixed self-assembled monolayers of thiols on gold. *Langmuir* **19**: 4351–4357.
657. Frederix F, Bonroy K, Reekmans G, Laureyn W, Campitelli A, Abramov MA, Dehaen W, Maes G. 2003. Reduced nonspecific adsorption on covalently immobilized protein surfaces using poly(ethylene oxide) containing blocking agents. *J. Biochem. Biophys. Meth.* **58**: 67–74.
658. Frey W, Meyer DE, Chilkoti A. 2003. Thermodynamically reversible addressing of a stimuli responsive fusion protein into a patterned surface template. *Langmuir* **19**: 1641–1653.
659. Gaidukov L, Fish A, Mor A. 2003. Analysis of membrane-binding properties of dermaseptin analogues: relationships between binding and cytotoxicity. *Biochemistry* **42**: 12866–12874.
660. Gozani O, Karuman P, Jones DR, Ivanov D, Cha J, Lugovskoy AA, Baird CL, Zhu H, Field SJ, Lessnick SL, Villasenor J, Mehrotra B, Chen J, Rao VR, Brugge JS, Ferguson CG, Payrastre B, Myszka DG, Cantley LC, Wagner G, Divecha N, Prestwich GD, Yuan J. 2003. The PHD finger of the chromatin-associated protein ING2 functions as a nuclear phosphoinositide receptor. *Cell* **114**: 99–111.
661. Granéli A, Rydström J, Kasemo B, Höök F. 2003. Formation of supported lipid bilayer membranes on SIO2 from proteoliposomes containing transmembrane proteins. *Langmuir* **19**: 842–850.
662. Gustafson I. 2003. Investigating the interaction of the toxin ricin and its B-chain with immobilised glycolipids in supported phospholipid membranes by surface plasmon resonance. *Colloids Surf. B* **30**: 13–24.
663. Hayashida O, Mizuki K, Akagi K, Matsuo A, Kanamori T, Nakai T, Sando S, Aoyama Y. 2003. Macrocyclic glycoclusters. self-aggregation and phosphate-induced agglutination behaviors of calix[4]resorcarene-based quadruple-chain amphiphiles with a huge oligosaccharide pool. *J. Am. Chem. Soc.* **125**: 594–601.
664. Hepbildikler SR, Wendeler M, Sandhoff R, Sandhoff K. 2003. Interaction of the G_{M2} activator protein with sulfated and sialylated glycosphingolipids. *Meth. Enzymol.* **363**: 207–222.
665. Hong M-Y, Yoon HC, Kim H-S. 2003. Protein-ligand interactions at poly(amidoamine) dendrimer monolayers on gold. *Langmuir* **19**: 416–421.
666. Houseman BT, Gawalt ES, Mrksich M. 2003. Maleimidefunctionalized self-assembled monolayers for the preparation of peptide and carbohydrate biochips. *Langmuir* **19**: 1522–1531.
667. Jiang X, Ferrigno R, Mrksich M, Whitesides GM. 2003. Electrochemical desorption of self-assembled monolayers noninvasively releases patterned cells from geometrical confinements. *J. Am. Chem. Soc.* **125**: 2366–2367.
668. Jin Y, Mozsolits H, Hammer J, Zmuda E, Zhu F, Zhang Y, Aguilar MI, Blazyk J. 2003. Influence of tryptophan on lipid binding of linear amphipathic cationic antimicrobial peptides. *Biochemistry* **42**: 9395–9405.
669. Jule E, Nagasaki Y, Kataoka K. 2003. Lactose-installed poly(ethylene glycol)-poly(D,L-lactide) block copolymer micelles exhibit fast-rate binding and high affinity toward a protein bed simulating a cell surface. A surface plasmon resonance study. *Bioconjug. Chem.* **14**: 177–186.
670. Kane RS, Deschatelets P, Whitesides GM. 2003. Kosmotropes form the basis of protein-resistant surfaces. *Langmuir* **19**: 2388–2391.
671. Kremer JJ, Murphy RM. 2003. Kinetics of adsorption of β-amyloid peptide Aβ(1–40) to lipid bilayers. *J. Biochem. Biophys. Meth.* **57**: 159–169.
672. Li L, Storm P, Karlsson OP, Berg S, Wieslander Å. 2003. Irreversible binding and activity control of the 1,2-diacylglycerol 3-glucosyltransferase from *Acholeplasma laidlawii* at an anionic lipid bilayer surface. *Biochemistry* **42**: 9677–9686.

673. MacLeod TJ, Kwon M, Filipenko NR, Waisman DM. 2003. Phospholipid-associated annexin A2-S100A10 heterotetramer and its subunits. *J. Biol. Chem.* **278**: 25577–25584.
674. Mangoni ML, Papo N, Mignogna G, Andreu D, Shai Y, Barra D, Simmaco M. 2003. Ranacyclins, a new family of short cyclic antimicrobial peptides: biological function, mode of action, and parameters involved in target specificity. *Biochemistry* **42**: 14023–14035.
675. Metallo SJ, Kane RS, Holmlin RE, Whitesides GM. 2003. Using bifunctional polymers presenting vancomycin and fluorescein groups to direct anit-fluorescein antibodies to self-assembled monolayers presenting D-alanine-D-alanine groups. *J. Am. Chem. Soc.* **125**: 4534–4540.
676. Metzke M, Bai JZ, Guan Z. 2003. A novel carbohydratederived side-chain polyether with excellent protein resistance. *J. Am. Chem. Soc.* **125**: 7760–7761.
677. Michael KE, Vernekar VN, Keselowsky BG, Meredith JC, Latour RA, García AJ. 2003. Adsorption-Induced conformational changes in fibronectin due to interactions with well-defined surface chemistries. *Langmuir* **19**: 8033–8040.
678. Nagahori N, Niikura K, Sadamoto R, Monde K, Nishimura S-I. 2003. Synthesis of photopolymerizable glycollpids and their application as scaffolds to immobilize proteins with a micron-sized pattern. *Australian J. Chem.* **56**: 567–576.
679. Nath N, Chilkoti A. 2003. Fabrication of a reversible protein array directly from cell lysate using a stimuliresponsive polypeptide. *Anal. Chem.* **75**: 709–715.
680. Ostuni E, Grzybowski BA, Mrksich M, Roberts CS, Whitesides GM. 2003. Adsorption of proteins to hydrophobic sites on mixed self-assembled monolayers. *Langmuir* **19**: 1861–1872.
681. Papo N, Shahar M, Eisenbach L, Shai Y. 2003. A novel lytic peptide composed of DL-amino acids selectively kills cancer cells in culture and in mice. *J. Biol. Chem.* **278**: 21018–21023.
682. Papo N, Shai Y. 2003. Exploring peptide membrane interaction using surface plasmon resonance: differentiation between pore formation versus membrane disruption by lytic peptides. *Biochemistry* **42**: 458–466.
683. Papo N, Shai Y. 2003. New lytic peptides based on the D,L-amphipathic helix motif preferentially kill tumor cells compared to normal cells. *Biochemistry* **42**: 9346–9354.
684. Peisajovich SG, Blank L, Epand RF, Epand RM, Shai Y. 2003. On the interaction between gp41 and membranes: the immunodominant loop stabilizes gp41 helical hairpin conformation. *J. Mol. Biol.* **326**: 1489–1501.
685. Peisajovich SG, Gallo SA, Blumenthal R, Shai Y. 2003. C-terminal octylation rescues an inactive T20 mutant. *J. Biol. Chem.* **278**: 21012–21017.
686. Peluso P, Wilson DS, Do D, Tran H, Venkatasubbaiah M, Quincy D, Heidecker B, Poindexter K, Tolani N, Phelan M, Witte K, Jung LS, Wagner P, Nock S. 2003. Optimizing antibody immobilization strategies for the construction of protein microarrays. *Anal. Biochem.* **312**: 113–124.
687. Rossman KL, Cheng L, Mahon GM, Rojas RJ, Snyder JT, Whitehead IP, Sondek J. 2003. Multifunctional roles for the PH domain of Dbs in regulating Rho GTPase activation. *J. Biol. Chem.* **278**: 18393–18400.
688. Satchell DP, Sheynis T, Kolusheva S, Cummings J, Vanderlick TK, Jelinek R, Selsted ME, Ouellette AJ. 2003. Quantitative interactions between cryptdin-4 amino terminal variants and membranes. *Peptides* **24**: 1795–1805.
689. Senin II, Vaganova SA, Weiergräber OH, Ergorov NS, Philippov PP, Koch K-W. 2003. Functional restoration of the Ca^{2+}-myristoyl switch in a recoverin mutant. *J. Mol. Biol.* **330**: 409–418.
690. Simmelink MJA, Derksen RHWM, Arnout J, De Groot PG. 2003. A simple method to discriminate between β_2-glycoprotein I- and prothrombin-dependent lupus anticoagulants. *J. Thromb. Haemost.* **1**: 740–747.
691. Slater SJ, Selz JL, Cook AC, Stagliano BA, Buzas CJ. 2003. Inhibition of protein kinase C by resveratrol. *Biochim. Biophys. Acta* **1637**: 59–69.
692. Smith JC, Lee K-B, Wang Q, Finn MG, Johnson JE, Mrksich M, Mirkin CA. 2003. Nanopatterning the chemospecific immobilization of cowpea mosaic virus capsid. *Nano Lett.* **3**: 883–886.
693. Sott K, Karlsson M, Pihl J, Hurtig J, Lobovkina T, Orwar O. 2003. Micropipet writing technique for production of two-dimensional lipid bilayer nanotube-vesicle networks on functionalized and patterned surfaces. *Langmuir* **19**: 3904–3910.
694. Stahelin RV, Burian A, Bruzik KS, Murray D, Cho W. 2003. Membrane binding mechanisms of the PX domains of NADPH oxidase $p40^{phox}$ and $p47^{phox}$. *J. Biol. Chem.* **278**: 14469–14479.
695. Stahelin RV, Long F, Peter BJ, Murray D, De Camilli P, McMahon HT, Cho W. 2003. Contrasting membrane interaction mechanisms of AP180 N-terminal homology (ANTH) and epsin N-terminal homology (ENTH) domains. *J. Biol. Chem.* **278**: 28993–28999.
696. Stahelin RV, Rafter JD, Das S, Cho W. 2003. The molecular basis of differential subcellular localization of C2 domains of protein kinase C-α and group IVa cytosolic phospholipase A_2. *J. Biol. Chem.* **278**: 12452–12460.
697. Stroock AD, Kane RS, Weck M, Metallo SJ, Whitesides GM. 2003. Synthesis of free-standing quasi-twodimensional polymers. *Langmuir* **19**: 2466–2472.
698. Subasinghe S, Unabia S, Barrow CJ, Mok SS, Aguilar MI, Small DH. 2003. Cholesterol is necessary both for the toxic effect of Aβ peptides on vascular smooth muscle cells and for Aβ binding to vascular smooth muscle cell membranes. *J. Neurochem.* **84**: 471–479.
699. Sun Y-H, Shen L, Dahlbäck B. 2003. Gla domain-mutated human protein C exhibiting enhanced anticoagulant activity and increased phospholipid binding. *Blood* **101**: 2277–2284.
700. Thomas CJ, Anbazhagan V, Ramakrishnan M, Sultan N, Surolia I, Swamy MJ. 2003. Mechanism of membrane binding by the bovine seminal plasma protein, PDC-109: a surface plasmon resonance study. *Biophys. J.* **84**: 3037–3044.
701. Thomas CJ, Sharma S, Kumar G, Visweswarial SS, Surolia A. 2003. Biopanning of endotoxin-specific phage display peptides. *Biochem. Biophys. Res. Commun.* **307**: 133–138.
702. Valdes-Gonzalez T, Inagawa J, Ido T. 2003. Characterization of the interactions of β-amyloid peptides with glycolipid receptors by surface plasmon resonance. *Spectroscopy* **17**: 241–254.
703. Yang SY, Mendelsohn JD, Rubner MF. 2003. New class of ultrathin, highly cell-adhesion-resistant polyelectrolyte multilayers with micropatterning capabilities. *Biomacromolecules* **4**: 987–994.
704. Zhu Y, Ho B, Ding JL. 2003. Sequence and structural diversity in endotoxin-binding dodecapeptides. *Biochim. Biophys. Acta* **1611**: 234–242.

Extracellular matrix.

705. Altroff H, Choulier L, Mardon HJ. 2003. Synergistic activity of the ninth and tenth FIII domains of human fibronectin depends upon structural stability. *J. Biol. Chem.* **278**: 491–497.
706. Barth H, Schäfer C, Adah MI, Zhang F, Linhardt RJ, Toyoda H, Kinoshita-Toyoda A, Toida T, van Kuppevelt TH, Depla E, von Weizsäcker F, Blum HE, Baumert TF. 2003. Cellular binding of hepatitis C virus envelope glycoprotein E2 requires cell surface heparan sulfate. *J. Biol. Chem.* **278**: 41003–41012.
707. Bonnefoy A, Yamamoto H, Thys C, Kito M, Vermylen J, Hoylaerts MF. 2003. Shielding the front-strand β3 of the von Willebrand factor A1 domain inhibits its binding to platelet glycoprotein Ibα. *Blood* **101**: 1375–1383.
708. Carrino DA, Önnerfjord P, Sandy JD, Cs-Szabo G, Scott PG, Sorrell JM, Heinegård D, Caplan AI. 2003. Age-related changes in the proteoglycans of human skin. *J. Biol. Chem.* **278**: 17566–17572.
709. Cochran S, Li C, Fairweather JK, Kett WC, Coombe DR, Ferro V. 2003. Probing the interactions of phosphosulfomannars with angiogenic growth factors by surface plasmon resonance. *J. Med. Chem.* **46**: 4601–4608.
710. Eckert R, Ragg H. 2003. Zinc ions promote the interaction between heparin and heparin cofactor II. *FEBS Lett.* **541**: 121–125.
711. Francis DJ, Parish CR, McGarry M, Santiago FS, Lowe HC, Brown KJ, Bingley JA, Hayward IP, Cowden WB, Campbell JH, Campbell GR, Chesterman CN, Khachigian LM. 2003.

Blockade of vascular smooth muscle cell proliferation and intimal thickening after balloon injury by the sulfated oligosaccharide PI-88. *Circul. Res.* **92**: e70–e77.
712. Garcia-Olivas R, Hoebeke J, Castel S, Reina M, Fager G, Lustig F, Vilaró S. 2003. Differential binding of plateletderived growth factor isoforms to glycosaminoglycans. *Histochem. Cell. Biol.* **120**: 371–382.
713. Gonzalez EM, Monglat M, Slater SJ, Baffa R, Iozzo RV. 2003. A novel interaction between perlecan protein core and progranulin. *J. Biol. Chem.* **278**: 38113–38116.
714. Hall AE, Domanski PJ, Patel PR, Vernachio JH, Syribeys PJ, Gorovits EL, Johnson MA, Ross JM, Hutchins JT, Patti JM. 2003. Characterization of a protective monoclonal antibody recognizing *Staphylococcus aureus* MSCRAMM protein clumping factor A. *Infect. Immun.* **71**: 6864–6870.
715. Heilmann C, Thumm G, Chhatwal GS, Hartleib J, Uekötter A, Peters G. 2003. Identification and characterization of a novel autolysin (Aae) with Adhesive properties from *Staphylococcus epidermidis*. *Microbiology* **149**: 2769–2778.
716. Kett WC, Osmond RIW, Moe L, Skett SE, Kinnear BF, Coombe DR. 2003. Avidin is a heparin-binding protein. Affinity, specificity and structural analysis. *Biochim. Biophys. Acta* **1620**: 225–234.
717. Kolev K, Tenekedjiev K, Ajtai K, Kovalszky I, Gombás J, Váradi B, Machovich R. 2003. Myosin: a non-covalent stabilizer of fibrin in the process of clot dissolution. *Blood* **101**: 4380–4386.
718. Lang K, Hatt H, Niggemann B, Zaenker KS, Entschladen F. 2003. A novel function for chemokines: downregulation of neutrophil migration. *Scand. J. Immunol.* **57**: 350–361.
719. Liu B, Weinzimer SA, Gibson TB, Mascarenhas D, Cohen P. 2003. Type Iβ collagen is an IGFBP-3 binding protein. *Growth Hormone IGF Res.* **13**: 89–97.
720. Lookene A, Zhang L, Tougu V, Olivecrona G. 2003. 1,1′-Bis(anilino)-4-,4′-bis(naphtalene)-8,8′-disulfonate acts as an inhibitor of liproprotein lipase and competes for binding with apolipoprotein CII. *J. Biol. Chem.* **278**: 37183–37194.
721. Maeda N, He J, Yajima Y, Mikami T, Sugahara K, Yabe T. 2003. Heterogeneity of the chondroitin sulfate portion of phosphacan/6B4 proteoglycan regulates its binding affinity for pleiotrophin/HB-GAM. *J. Biol. Chem.* **278**: 35805–35811.
722. Margosio B, Marchetti D, Vergani V, Giavazzi R, Rusnati M, Presta M, Taraboletti G. 2003. Thrombospondin 1 as a scavenger for matrix-associated fibroblast growth factor 2. *Blood* **102**: 4399–4406.
723. Matsumoto K, Shionyu M, Go M, Shimizu K, Shinomura T, Kimata K, Watanabe H. 2003. Distinct interaction of versican / PG-M with hyaluronan and link protein. *J. Biol. Chem.* **278**: 41205–41212.
724. Merkulova-Rainon T, England P, Ding S, Demerens C, Tobelem G. 2003. The N-terminal domain of hepatocyte growth factor inhibits the angiogenic behavior of endothelial cells independently from binding to the c-met receptor. *J. Biol. Chem.* **278**: 37400–37408.
725. Mould AP, Barton SJ, Askari JA, Craig SE, Humphries MJ. 2003. Role of ADMIDAS cation-binding site in ligand recognition by integrin $\alpha_5\beta_1$. *J. Biol. Chem.* **278**: 51622–51629.
726. Muramatsu T, Muramatsu H, Kaneda N, Sugahara K. 2003. Recognition of glycosaminoglycans by midkine. *Meth. Enzymol.* **363**: 365–377.
727. Nakamura A, Nukiwa T, Takai T. 2003. Deregulation of peripheral B-cell development in enhanced severity of collagen-induced arthritis in FcγRIIB-deficient mice. *J. Autoimmunity* **20**: 227–236.
728. Nishida N, Sumikawa H, Sakakura M, Shimba N, Takahashi H, Terasawa H, Suzuki E-i, Shimada I. 2003. Collagen-binding mode of vWF-A3 domain determined by a transferred cross-saturation experiment. *Nat. Struct. Biol.* **10**: 53–58.
729. Okamoto O, Bachy S, Odenthal U, Bernaud J, Rigal D, Lortat-Jacob H, Smyth N, Rousselle P. 2003. Normal human keratinocytes bind to the α3LG4/5 domain of unprocessed laminin-5 through the receptor syndecan-1. *J. Biol. Chem.* **278**: 44168–44177.
730. Oksjoki R, Jarva H, Kovanen PT, Laine P, Meri S, Pentikäinen MO. 2003. Association between complement factor H and proteoglycans in early human coronary atherosclerotic lesions. *Arterioscler. Thromb. Vasc. Biol.* **23**: 630–636.
731. Petersen SV, Valnickova Z, Enghild JJ. 2003. Pigmentepithelium-derived factor (PEDF) occurs at a physiologically relevant concentration in human blood: purification and characterization. *Biochem. J.* **374**: 199–206.
732. Philippou H, Rance J, Myles T, Hall SW, Ariens RA, Grant PJ, Leung L, Lane DA. 2003. Roles of low specificity and cofactor interaction sites on thrombin during factor XIII activation. *J. Biol. Chem.* **278**: 32020–32026.
733. Pixley RA, Lin Y, Isordia-Salas I, Colman RW. 2003. Fine mapping of the sequences in domain 5 of higher molecular weight kininogen (HK) interacting with heparin and zinc. *J. Thromb. Haemost.* **1**: 1791–1798.
734. Ponnuraj K, Bowden MG, Davis S, Gurusiddappa S, Moore D, Choe D, Xu Y, Hook M, Narayana SVL. 2003. A 'dock, lock, and latch' structural model for a staphylococcal adhesin binding to fibrinogen. *Cell* **115**: 217–228.
735. Rathore D, Hrstka SCL, Sacci JB Jr, De la Vega P, Linhardt RJ, Kumar S, McCutchan TF. 2003. Molecular mechanism of host specificity in *Plasmodium falciparum* infection. *J. Biol. Chem.* **278**: 40905–40910.
736. Romijn RA, Westein E, Bouma B, Schiphorst ME, Sixma JJ, Lenting PJ, Huizinga EG. 2003. Mapping the collagenbinding site in the von Willebrand factor A3-domain. *J. Biol. Chem.* **278**: 15035–15039.
737. Scholefield Z, Yates EA, Wayne G, Amour A, McDowell W, Turnbull JE. 2003. Heparan sulfate regulates amyloid precursor protein processing by BACE1, the Alzheimer's β-secretase. *J. Cell Biol.* **163**: 97–107.
738. Sheehan JP, Kobbervig CE, Kirkpatrick HM. 2003. Heparin inhibits the intrinsic tenase complex by interacting with an exosite on factor IXa. *Biochemistry* **42**: 11316–11325.
739. Smith SA, Sreenivasan R, Krishnasamy G, Judge KW, Murthy KH, Arjunwadkar SJ, Pugh DR, Kotwal GJ. 2003. Mapping of regions within the vaccinia virus complement control protein involved in dose-dependent binding to key complement components and heparin using surface plasmon resonance. *Biochim. Biophys. Acta* **1650**: 30–39.
740. Stork J, Hoffmann T, Demuth H-U. 2003. Investigation of DP IV-dependent protein-protein interactions using surface plasmon resonance. *Adv. Exp. Med. Biol.* **524**: 115–119.
741. Suzuki N, Ichikawa N, Kasai S, Yamada M, Nishi N, Morioka H, Yamashita H, Kitagawa Y, Utani A, Hoffmann MP, Nomizu M. 2003. Syndecan binding sites in the laminin α1 chain G domain. *Biochemistry* **42**: 12625–12633.
742. Takagi J, Strokovich K, Springer TA, Walz T. 2003. Structure of integrin á5β1 in complex with fibronectin. *EMBO J.* **22**: 4607–4615.
743. Takeda M, Terasawa H, Sakakura M, Yamaguchi Y, Kajiwara M, Kawashima H, Miyasaka M, Shimada I. 2003. Hyaluronan recognition mode of CD44 revealed by cross-saturation and chemical shift perturbation experiments. *J. Biol. Chem.* **278**: 43550–43555.
744. Wang J-G, Geng J-G. 2003. Affinity and kinetics of Pselectin binding to heparin. *Thromb. Haemost.* **90**: 309–316.
745. Wiberg C, Klatt AR, Wagener R, Paulsson M, Bateman JF, Heinegård D, Mörgelin M. 2003. Complexes of matrilin-1 and biglycan or decorin connect collagen VI microfibrils to both collagen II and aggrecan. *J. Biol. Chem.* **278**: 37698–37704.
746. Wilson JJ, Matsushita O, Okabe A, Sakon J. 2003. A bacterial collagen-binding domain with novel calcium-binding motif controls domain orientation. *EMBO J.* **22**: 1743–1752.
747. Xiang Y, Moss B. 2003. Molluscum contagiosum virus interleukin-18 (IL-18) binding protein is secreted as a full-length form that binds cell surface glycosaminoglycans through the C-terminal tail and a furin-cleaved form with only the IL-18 binding domain. *J. Virol.* **77**: 2623–2630.
748. Yakovlev S, Gorlatov S, Ingham K, Medved L. 2003. Interaction of fibrin(ogen) with heparin: further characterization and localization of the heparin-binding site. *Biochemistry* **42**: 7709–7716.

749. Zamurs L, Pouliot N, Gibson P, Hocking G, Nice E. 2003. Strategies for the purification of laminin-10 for studies on colon caner metastasis. *Biomed. Chromatogr.* **17**: 201–211.

Carbohydrates.

750. Blixt O, Collins BE, van den Nieuwenhof IM, Crocker PR, Paulson JC. 2003. Sialoside specificity of the Siglec family assessed using novel multivalent probes. *J. Biol. Chem.* **278**: 31007–31019.
751. Candy L, Van Damme EJM, Peumans WJ, Menu-Bouaouiche L, Erard M, Rougé P. 2003. Structural and functional characterization of the GalNAc/Gal-specific lectin from the phytopathogenic ascomycete *Sclerotinia sclerotiorum* (Lib.) de Bary. *Biochem. Biophys. Res. Commun.* **308**: 396–402.
752. Frison N, Taylor ME, Soilleux E, Bousser M-T, Mayer R, Monsigny M, Drickamer K, Roche A-C. 2003. Oligolysine-based oligosaccharide clusters. *J. Biol. Chem.* **278**: 23922–23929.
753. Gao C-X, Honke K, Taniguchi N. 2003. Carbohydrate binding activity of annexin V toward a bisecting Nacetylglucosamine. *Meth. Enzymol.* **363**: 34–47.
754. Halkes KM, St Hilaire PM, Crocker PR, Meldal M. 2003. Glycopeptides as oligosaccharide mimics: high affinity sialopeptide ligands for sialoadhesin from combinatorial libraries. *J. Comb. Chem.* **5**: 18–27.
755. Ideo H, Seko A, Ishizuka I, Yamashita K. 2003. The *N*-terminal carbohydrate recognition domain of galectin-8 recognizes specific glycosphingolipids with high affinity. *Glycobiology* **13**: 713–723.
756. Kakinuma Y, Endo Y, Takahashi M, Nakata M, Matsushita M, Takenoshita S, Fujita T. 2003. Molecular cloning and characterization of novel ficolins from *Xenopus laevis*. *Immunogenetics* **55**: 29–37.
757. Koyanagi S, Tanigawa N, Nakagawa H, Soeda S, Shimeno H. 2003. Oversulfation of fucoidan enhances its anti-angiogenic and antitumor activities. *Biochem. Pharmac.* **65**: 173–179.
758. Larsson A, Ohlsson J, Dodson KW, Hultgren SJ, Nilsson U, Kihlberg J. 2003. Quantitative studies of the binding of the class II PapG adhesin from uropathogenic *Escherichia coli* to oligosaccharides. *Bioorg. Med. Chem.* **11**: 2255–2261.
759. Meiyu G, Fuchuan L, Xianliang X, Jing L, Zuowei Y, Huashi G. 2003. The potential molecular targets of marine sulfated polymannuroguluronate interfering with HIV-1 entry. Interaction between SPMG and HIV-1 rgp120 and CD4 molecule. *Antiviral. Res.* **59**: 127–135.
760. Müller-Loennies S, Brade L, MacKenzie CR, Di Padova FE, Brade H. 2003. Identification of a cross-reactive epitope widely present in lipopolysaccharide from enterobacteria and recognized by the cross-protective monoclonal antibody WN1 222–5. *J. Biol. Chem.* **278**: 25618–25627.
761. Nadesalingam J, Bernal AL, Dodds AW, Willis AC, Mahoney DJ, Day AJ, Reid KBM, Palaniyar N. 2003. Identification and characterization of a novel interaction between pulmonary surfactant protein D and decorin. *J. Biol. Chem.* **278**: 25678–25687.
762. Nagahori N, Nilkura K, Sadamoto R, Taniguchi M, Yamagishi A, Monde K, Nishimura S-I. 2003. Glycosyltransferase microarray displayed on the glycolipid LB membrane. *Adv. Synth. Catal.* **345**: 729–734.
763. Naus CWA, van Remoortere A, Ouma JH, Kimani G, Dunne DW, Kamerling JP, Deelder AM, Hokke CH. 2003. Specific antibody responses to three schistosome-related carbohydrate structures in recently exposed immigrants and established residents in an area of *Schistosoma mansoni* endemicity. *Infect. Immun.* **71**: 5676–5681.
764. Patil AR, Misquith S, Dam TK, Sharma V, Kapoor M, Surolia A. 2003. Exploring enzyme amplification to characterize specificities of protein-carbohydrate recognition. *Meth. Enzymol.* **362**: 567–583.
765. Roseman DS, Baenziger JU. 2003. The Man/GalNAc-4-SO_4-receptor: relating specificity to function. *Meth. Enzymol.* **363**: 121–133.
766. Sengupta K, Schilling J, Marx S, Fischer M, Bacher A, Sackmann E. 2003. Mimicking tissue surfaces by supported membrane coupled ultrathin layer of hyaluronic acid. *Langmuir* **19**: 1775–1781.
767. Shen B, Shimmon S, Smith MM, Ghosh P. 2003. Biosensor analysis of the molecular interactions of pentosan polysulfate and of sulfated glycosaminoglycans with immobilized elastase, hyaluronidase and lysozyme using surface plasmon resonance (SPR) technology. *J. Pharm. Biomed. Anal.* **31**: 83–93.
768. Telmer PG, Shilton BH. 2003. Insights into the conformational equilibria of maltose-binding protein by analysis of high affinity mutants. *J. Biol. Chem.* **278**: 34555–34567.
769. Ueda H, Takahashi N, Ogawa H. 2003. *Psathyrella velutina* lectin as a specific probe for *N*-acetylneuraminic acid in glycoconjugates. *Meth. Enzymol.* **363**: 77–91.
770. Wang L, Geng M, Li J, Guan H, Ding J. 2003. Studies of marine sulfated polymannuroguluronate on endothelial cell proliferation and endothelial immunity and related mechanisms. *J. Pharmac. Sci.* **92**: 367–373.
771. Wimmerova M, Mitchell E, Sanchez J-F, Gautier C, Imberty A. 2003. Crystal structure of fungal lectin. *J. Biol. Chem.* **278**: 27059–27067.

Small molecules.

772. Ahmad A, Ramakrishnan A, McLean MA, Breau AP. 2003. Use of surface plasmon resonance biosensor technology as a possible alternative to detect differences in binding of enantiomeric drug compounds to immobilized albumins. *Biosens. Bioelectron.* **18**: 399–404.
773. Arkin MR, Randal M, DeLano WL, Hyde J, Luong TN, Oslob JD, Raphael DR, Taylor L, Wang J, McDowell RS, Wells JA, Braisted AC. 2003. Binding of small molecules to an adaptive protein-protein interface. *Proc. Natl. Acad. Sci. USA* **100**: 1603–1608.
774. Backman D, Danielson UH. 2003. Kinetic and mechanistic analysis of the association and dissociation of inhibitors interacting with secreted aspartic acid proteases 1 and 2 from *Candida albicans*. *Biochim. Biophys. Acta* **1646**: 184–195.
775. Braisted AC, Oslob JD, DeLano WL, Hyde J, McDowell RS, Waal N, Yu C, Arkin MR, Raimundo BC. 2003. Discovery of a potent small molecule IL-2 inhibitor through fragment assembly. *J. Am. Chem. Soc.* **125**: 3714–3715.
776. Breitenlechner C, Gaßel M, Hidaka H, Kinzel V, Huber R, Engh RA, Bossemeyer D. 2003. Protein kinase A in complex with Rho-kinase inhibitors Y-27632, Fasudil, and H-1152P: structural basis of selectivity. *Structure* **11**: 1595–1607.
777. Brown SE, Easton CJ, Kelly JB. 2003. Surface plasmon resonance to determine apparent stability constants for the binding of cyclodextrins to small immobilized guests. *J. Incl. Phenom. Macrocyc. Chem.* **46**: 167–173.
778. Cama E, Shin H, Christianson DW. 2003. Design of amino acid sulfonamides as transition-state analogue inhibitors of arginase. *J. Am. Chem. Soc.* **125**: 13052–13057.
779. Cannon MJ, Myszka DG. 2003. Analyzing the binding of low molecular mass compounds using Biacore S51. *Recent Res. Dev. Biophys. Biochem.* **3**: 333–344.
780. Carrasco C, Helissey P, Haroun M, Baldeyrou B, Lansiaux A, Colson P, Houssier C, Giorgi-Renault S, Bailly C. 2003. Design of a composite ethidium-netropsin-anilinoacridine molecule for DNA recognition. *ChemBiochem* **4**: 50–61.
781. Carrasco C, Joubert A, Tardy C, Maestre N, Cacho M, Braña MF, Bailly C. 2003. DNA sequence recognition by bispyrazinonaphthalimides antitumor agents. *Biochemistry* **42**: 11751–11761.
782. Day YSN, Myszka DG. 2003. Characterizing a drug's primary binding site on albumin. *J. Pharm. Sci.* **92**: 333–343.
783. Ding S, Wu TYH, Brinker A, Peters EC, Hur W, Gray NS, Schultz PG. 2003. Synthetic small molecules that control stem cell fate. *Proc. Natl. Acad. Sci. USA* **100**: 7632–7637.
784. Duncan SJ, Cooper MA, Williams DH. 2003. Binding of an inhibitor of the p53/MDM2 interaction to MDM2. *Chem. Commun. (Camb.)* **3**: 316–317.
785. Emtenäs H, Carlsson M, Pinkner JS, Hultgren SJ, Almqvist F. 2003. Stereoselective synthesis of optically active bicyclic β-lactam carboxylic acids that target pilus biogenesis in pathogenic bacteria. *Org. Biomol. Chem.* **1**: 1308–1314.
786. Facompré M, Carrasco C, Vezin H, Chisholm JD, Yoburn JC, Van Vranken DL, Bailly C. 2003. Indolocarbazole glycosides in inactive conformations. *ChemBiochem* **4**: 386–395.

787. Gaßel M, Breitenlechner CB, Rüger P, Jucknischke U, Schneider T, Huber R, Bossemeyer D, Engh RA. 2003. Mutants of protein kinase A that mimic the ATP-binding site of protein kinase B (AKT). *J. Mol. Biol.* **329**: 1021–1034.
788. Gossas T, Danielson UH. 2003. Analysis of the pH-dependencies of the association and dissociation kinetics of HIV-1 protease inhibitors. *J. Mol. Recognit.* **16**: 203–212.
789. Harris LC, Davis PJ, James DC. 2003. Fatty acids as haptens: exploring the limits of antigenicity. *Mol. Immunol.* **40**: 381–389.
790. Harrison RJ, Cuesta J, Chessari G, Read MA, Basra SK, Reszka AP, Morrell J, Gowan SM, Incles CM, Tanious FA, Wilson WD, Kelland LR, Neidle S. 2003. Trisubstituted acridine derivatives as potent and selective telomerase inhibitors. *J. Med. Chem.* **46**: 4463–4476.
791. Hauptmann H, Metzger J, Schnitzbauer A, Cuilleron CY, Mappus E, Luppa PB. 2003. Syntheses and ligand-binding studies of 1α- and 17α-aminoalkyl dihydrotestosterone derivatives to human sex hormone-binding globulin. *Steroids* **68**: 629–639.
792. He M, Burghardt TP, Vockley J. 2003. A novel approach to the characterization of substrate specificity in short/branched chain Acyl-CoA dehydrogenase. *J. Biol. Chem.* **278**: 37974–37986.
793. Heyd B, Pecorari F, Collinet B, Adjadj E, Desmadril M, Minard P. 2003. In vitro evolution of the binding specificity of neocarzinostatin, an enediyne-binding chromoprotein. *Biochemistry* **42**: 5674–5683.
794. Hisano M, Yamaguchi K, Inoue Y, Ikeda Y, Iijima M, Adachi M, Shimamura T. 2003. Inhibitory effect of catechin against the superantigen staphylococcal enterotoxin B (SEB). *Arch. Dermatol. Res.* **295**: 183–189.
795. Hyde J, Braisted AC, Randal M, Arkin MR. 2003. Discovery and characterization of cooperative ligand binding in the adaptive region of interleukin-2. *Biochemistry* **42**: 6475–6483.
796. Jain RK, Trias J, Ellman JA. 2003. D-Ala-D-Lac binding is not required for the high activity of vancomycin dimers against vancomycin resistant enterococci. *J. Am. Chem. Soc.* **125**: 8740–8741.
797. Koehler AN, Shamji AF, Schreiber SL. 2003. Discovery of an inhibitor of a transcription factor using small molecule microarrays and diversity-oriented synthesis. *J. Am. Chem. Soc.* **125**: 8420–8421.
798. Koh DW, Patel CN, Ramsinghani S, Slama JT, Oliveira MA, Jacobson MK. 2003. Identification of an inhibitor binding site of poly(ADP-ribose) glycohydrolase. *Biochemistry* **42**: 4855–4863.
799. Lange G, Lesuisse D, Deprez P, Schoot B, Loenze P, Benard D, Marquette J-P, Broto P, Sarubbi E, Mandine E. 2003. Requirements for specific binding of low affinity inhibitor fragments to the SH2 domain of ^{pp60}Src are identical to those for high affinity binding of full length inhibitors. *J. Med. Chem.* **46**: 5184–5195.
800. Lee S-H, Youk E-S, Lee H-J, Kho Y-H, Kim HM, Kim S-U. 2003. Dykellic acid inhibits drug-induced caspase-3-like protease activation. *Biochem. Biophys. Res. Commun.* **302**: 539–544.
801. Maiti S, Chaudhury NK, Chowdhury S. 2003. Hoechst 33258 binds to G-quadruplex in the promoter region of human *c-myc*. *Biochem. Biophys. Res. Commun.* **310**: 505–512.
802. Metzger J, Schnitzbauer A, Meyer M, Söder M, Cuilleron CY, Hauptmann H, Huber E, Luppa PB. 2003. Binding analysis of 1α- and 17α-dihydrotestosterone derivatives to homodimeric sex hormone-binding globulin. *Biochemistry* **42**: 13735–13745.
803. Mizushina Y, Ishidoh T, Kamisuki S, Nakazawa S, Takemura M, Sugawara F, Yoshida H, Sakaguchi K. 2003. Flavonoid glycoside: a new inhibitor of eukaryotic DNA polymerase α and a new carrier for inhibitor-affinity chromatography. *Biochem. Biophys. Res. Commun.* **301**: 480–487.
804. Mizushina Y, Murakami C, Takikawa H, Kasai N, Xu X, Mori K, Oshige M, Yamaguchi T, Saneyoshi M, Shimazaki N, Koiwai O, Yoshida H, Sugawara F, Sakaguchi K. 2003. Molecular action mode of hippospongic acid A, an inhibitor of gastrulation of starfish embryos. *J. Biochem.* **133**: 541–552.
805. Myszka DG, Abdiche YN, Arisaka F, Byron O, Eisenstein E, Hensley P, Thomson JA, Lombardo CR, Schwarz F, Stafford W, Doyle ML. 2003. The ABRF-MIRG' 02 study: assembly state, thermodynamic, and kinetic analysis of an enzyme/inhibitor interaction. *J. Biomol. Techniq.* **14**: 247–269.
806. Noble CG, Barnard FM, Maxwell A. 2003. Quinolone-DNA interaction: sequence-dependent binding to single-stranded DNA reflects the interaction within the gyrase-DNA complex. *Antimicrob. Agents Chemother.* **47**: 854–862.
807. Oda Y, Owa T, Sato T, Boucher B, Daniels S, Yamanaka H, Shinohara Y, Yokoi A, Kuromitsu J, Nagasu T. 2002. Quantitative chemical proteomics for identifying candidate drug targets. *Anal. Chem.* **75**: 2159–2165.
808. Park J, Fu H, Pei D. 2003. Peptidyl aldehydes as reversible covalent inhibitors of SRC homology 2 domains. *Biochemistry* **42**: 5159–5167.
809. Shi Z-D, Lee K, Liu H, Zhang M, Roberts LR, Worthy KM, Fivash MJ, Fisher RJ, Yang D, Burke TR, Jr. 2003. A novel macrocyclic tetrapeptide mimetic that exhibits low-picomolar Grb2 SH2 domain-binding affinity. *Biochem. Biophys. Res. Commun.* **310**: 378–383.
810. Shibata Y, Hiratsuka K, Hayakawa M, Shiroza T, Takiguchi H, Nagatsuka Y, Abiko Y. 2003. A 35-kDa coaggregation factor is a hemin binding protein in *Porphyromonas gingivalis*. *Biochem. Biophys. Res. Commun.* **300**: 351–356.
811. Shim JS, Kim JH, Cho HY, Yum YN, Kim SH, Park H-J, Shim BS, Choi SH, Kwon HJ. 2003. Irreversible inhibition of CD13/aminopeptidase N by the antiangiogenic agent curcumin. *Chem. Biol.* **10**: 695–704.
812. Shumann CF, Markgren P-O, Hämäläinen M, Danielson UH. 2003. Elucidation of HIV-1 protease resistance by characterization of interaction kinetics between inhibitors and enzyme variants. *Antiviral Res.* **58**: 235–242.
813. Solstad T, Stokka AJ, Andersen OA, Flatmark T. 2003. Studies on the regulatory properties of the pterin cofactor and dopamine bound at the active site of human phenylalanine hydroxylase. *Eur. J. Biochem.* **270**: 981–990.
814. Stokka AJ, Flatmark T. 2003. Substrate-induced conformational transition in human phenylalanine hydroxylase as studied by surface plasmon resonance analyses: the effect of terminal deletions, substrate analogues and phosphorylation. *Biochem. J.* **369**: 509–518.
815. Tanious F, Wilson WD, Wang L, Kumar A, Boykin DW, Marty C, Baldeyrou B, Bailly C. 2003. Cooperative dimerization of a heterocyclic diamidine determines sequence-specific DNA recognition. *Biochemistry* **42**: 13576–13586.
816. Thoma R, Löffler B, Stihle M, Huber W, Ruf A, Hennig M. 2003. Structural basis of proline-specific exopeptidase activity as observed in human dipeptidyl peptidase-IV. *Structure* **11**: 947–959.
817. Westerfors M, Tedebark U, Andersson HO, Öhrman S, Choudhury D, Ersoy O, Shinohara Y, Axén A, Carredano E, Baumann H. 2003. Structure-based discovery of a new affinity ligand to pancreatic alpha-amylase. *J. Mol. Recognit.* **16**: 396–405.

Clinical support.

818. Dekker S, Toussaint W, Panayotou G, de Wit T, Visser P, Grosveld F, Drabek D. 2003. Intracellularly expressed single-domain antibody against p15 matrix protein prevents the production of porcine retroviruses. *J. Virol.* **77**: 12132–12139.
819. Dillon PP, Daly SJ, Manning BM, O'Kennedy R. 2003. Immunoassay for the determination of morphine-3-glucuronide using a surface plasmon resonance-based biosensor. *Biosens. Bioelectron.* **18**: 217–227.
820. Dillon PP, Manning BM, Daly SJ, Killard AJ, O'Kennedy R. 2003. Production of a recombinant anti-morphine-3-glucuronide single-chain variable fragment (scFv) antibody for the development of a 'real-time' biosensorbased immunoassay. *J. Immunol. Meth.* **276**: 151–161.
821. Green MD, Koelbl H, Baselga J, Galid A, Guillem V, Gascon P, Siena S, Lalisang RI, Samonigg H, Clemens MR, Zani V, Liang BC, Renwick J, Piccart MJ. 2003. A randomized double-blind multicenter phase III study of fixed-dose single-administration pegfilgrastim versus daily filgrastim in patients receiving myelosuppressive chemotherapy. *Ann. Oncol.* **14**: 29–35.
822. Hudson CA, Cao L, Kasten-Jolly J, Kirkwood JN, Lawrence DA. 2003. Susceptibility of lupus-prone NZM mouse strains to lead

exacerbation of systemic lupus erythematosus symptoms. *J. Toxicol. Environ. Health A* **66**: 895–918.
823. Jambou F, Zhang W, Menestrier M, Klingel-Schmitt I, Michel O, Caillat-Zucman S, Aissaoui A, Landermarre L, Berrih-Aknin S, Cohen-Kaminsky S. 2003. Circulating regulatory anti-T cell receptor antibodies in patients with myasthenia gravis. *J. Clin. Invest.* **112**: 265–274.
824. Kim J-Y, Lee M-H, Jung K-I, Na HY, Cha H-S, Ko E-M, Kim TJ. 2003. Detection of antibodies against glucose 6-phosphate isomerase in synovial fluid of rheumatoid arthritis using surface plasmon resonance (BIAcore). *Exp. Mol. Med.* **35**: 310–316.
825. Kips JC, O'Connor BJ, Langley SJ, Woodcock A, Kerstjens HAM, Postma DS, Danzig M, Cuss F, Pauwels RA. 2003. Effect of SCH55700, a humanized anti-human interleukin-5 antibody, in severe persistent asthma. *Am. J. Respir. Crit. Care Med.* **167**: 1655–1659.
826. Lung F-DT, Chen H-Y, Lin H-T. 2003. Monitoring bone loss using ELISA and surface plasmon resonance (SPR) technology. *Prot. Pept. Lett.* **10**: 313–319.
827. Mason S, La S, Mytych D, Swanson SJ, Ferbas J. 2003. Validation of the BIACORE 3000 platform for detection of antibodies against erythropoietic agents in human serum samples. *Curr. Med. Res. Opin.* **19**: 651–659.
828. Mobini R, Staudt A, Felix SB, Baumann G, Wallukat G, Deinum J, Svensson H, Hjalmarson Å, Fu M. 2003. Hemodynamic improvement and removal of autoantibodies against β_1-adrenergic receptor by immunoadsorption therapy in dilated cardiomyopathy. *J. Autoimmunity* **20**: 345–350.
829. Novotny LA, Bakaletz LO. 2003. The fourth surface-exposed region of the outer membrane protein P5-homologous adhesin of nontypable *Haemophilus influenzae* is an immunodominant but nonprotective decoying epitope. *J. Immunol.* **171**: 1978–1983.
830. Regnault V, de Maistre E, Carteaux J-P, Gruel Y, Nguyen P, Tardy B, Lecompte T. 2003. Platelet activation induced by human antibodies to interleukin-8. *Blood* **101**: 1419–1421.
831. Rojo N, Ercilla G, Haro I. 2003. GB virus C (GBV-C)/hepatitis G virus (HGV): towards the design of synthetic peptides-based biosensors for immunodiagnosis of GBV-C/HGV infection. *Curr. Prot. Pept. Sci.* **4**: 291–298.
832. Schmechel A, Zentgraf H, Scheuermann S, Fritz G, Pipkorn R, Reed J, Beyreuther K, Bayer TA, Multhaup G. 2003. Alzheimer's β-amyloid homodimers facilitate Aβ fibrillization and the generation of conformational antibodies. *J. Biol. Chem.* **278**: 35317–35324.
833. Scott AM, Wiseman G, Welt S, Adjei A, Lee F-T, Hopkins W, Divgi CR, Hanson LH, Mitchell P, Gansen DN, Larson SM, Ingle JN, Hoffman EW, Transwell P, Ritter G, Cohen LS, Bette P, Arvay L, Amelsberg A, Vlock D, Rettig WJ, Old LJ. 2003. A phase I dose-escalation study of sibrotuzumab in patients with advanced or metastatic fibroblast activation protein-positive cancer. *Clin. Cancer Res.* **9**: 1639–1647.
834. Scott KA, Moore RJ, Arnott CH, East N, Thompson RG, Scallon BJ, Shealy DJ, Balkwill FR. 2003. An anti-tumor necrosis factor-α anibody inhibits the development of experimental skin tumors. *Mol. Cancer Ther.* **2**: 445–451.
835. Sellborn A, Andersson M, Fant C, Gretzer C, Elwing H. 2003. Methods for research on immune complement activation on modified sensor surfaces. *Colloids Surf. B* **27**: 295–301.
836. Skeie GO, Mygland Å, Treves S, Gilhus NE, Aarli JA, Zorzato F. 2003. Ryanodine receptor antibodies in myasthenia gravis: epitope mapping and effect on calcium release *in vitro*. *Muscle Nerve* **27**: 81–89.
837. van Remoortere A, Vermeer HJ, van Roon AM, Langermans JA, Thomas AW, Wilson RA, van Die I, van den Eijnden DH, Ágoston K, Kérèkgyarto J, Vliegenthart JFG, Kamerling JP, van Dam GJ, Hokke CH, Deelder AM. 2003. Dominant antibody responses to Fucα1-3GalNAc and Fucα1-2Fucα1-3GlcNAc containing carbohydrate epitopes in *Pan troglodytes* vaccinated and infected with *Schistosoma mansoni*. *Exp. Parasit.* **105**: 219–225.
838. Vermeer HJ, van Dam GJ, Halkes KM, Kamerling JP, Vliegenthart JF, Hokke CH, Deelder AM. 2003. Immunodiagnostically applicable monoclonal antibodies to the circulating anodic antigen of *Schistosoma mansoni* bind to small, defined oligosaccharide epitopes. *Parasitol. Res.* **90**: 330–336.
839. Welt S, Ritter G, Williams Jr C, Cohen LS, John M, Jungbluth A, Richards EA, Old LJ, Kemeny NE. 2003. Phase I study of anticolon cancer humanized antibody a33. *Clin. Cancer Res.* **9**: 1338–1346.
840. Welt S, Ritter G, Williams Jr C, Cohen LS, Jungbluth A, Richards EA, Old LJ, Kemeny NE. 2003. Preliminary report of a phase I study of combination chemotherapy and humanized A33 antibody immunotherapy in patients with advanced colorectal caner. *Clin. Cancer Res.* **9**: 1347–1353.

Food science, veterinary medicine, and environmental testing.

841. Crooks SRH, McCarney B, Traynor IM, Thompson CS, Floyd S, Elliott CT. 2003. Detection of levamisole residues in bovine liver and milk by immunobiosensor. *Anal. Chim. Acta* **483**: 181–186.
842. Dillon PP, Daly SJ, Killard AJ, O'Kennedy R. 2003. Development and use of antibodies in surface plasmon resonance-based immunosensors for environmental monitoring. *Intl. J. Environ. Anal. Chem.* **83**: 525–543.
843. Feriotto G, Gardenghi S, Bianchi N, Gambari R. 2003. Quantitation of Bt-176 maize genomic sequences by surface plasmon resonance-based biospecific interaction analysis of multiplex polymerase chain reaction (PCR). *J. Agric. Food Chem.* **51**: 4640–4646.
844. Haasnoot W, Bienenmann-Ploum M, Kohen F. 2003. Biosensor immunoassay for the detection of eight sulfonamides in chicken serum. *Anal. Chim. Acta* **483**: 171–180.
845. Haasnoot W, Cazemier G, Koets M, van Amerongen A. 2003. Single biosensor immunoassay for the detection of five aminoglycosides in reconstituted skimmed milk. *Anal. Chim. Acta* **488**: 53–60.
846. Hervé V, Roy F, Bertin J, Guillou F, Maurel MC. 2003. Antiequine chorionic gonadotropin (eCG) antibodies generated in goats treated with eCG for the induction of ovulation modulate the luteinizing hormone and follicle-stimulating hormone bioactivities of eCG differently. *Endocrinology* **145**: 294–303.
847. Indyk HE, Filonzi EL. 2003. Determination of immunoglobulin G in bovine colostrum and milk by direct biosensor SPR-immunoassay. *J. AOAC Int.* **86**: 386–393.
848. McCarney B, Traynor IM, Fodey TL, Crooks SRH, Elliott CT. 2003. Surface plasmon resonance biosensor screening of poultry liver and eggs for nicarbazin residues. *Anal. Chim. Acta* **483**: 165–169.
849. Medina MB. 2003. Detection of staphylococcal enterotoxin B (SEB) with surface plasmon resonance biosensor. *J. Rapid Meth. Autom. Microbiol.* **11**: 225–243.
850. Nakamura C, Hasegawa M, Nakamura N, Miyake J. 2003. Rapid and specific detection of herbicides using a self-assembled photosynthetic reaction center from purple bacterium on an SPR chip. *Biosens. Bioelectron.* **18**: 599–603.
851. Nygren L, Sternesjo Å, Björck L. 2003. Determination of folate-binding proteins from milk by optical biosensor analysis. *Intl. Dairy J.* **13**: 283–290.
852. Shelver W, Smith DJ. 2003. Determination of ractopamine in cattle and sheep urine samples using an optical biosensor analysis: comparative study with HPLC and ELISA. *J. Agric. Food Chem.* **51**: 3715–3721.
853. Stenberg E. 2003. Determination of B-vitamin concentrations in nutritional products using Biacore's SPR technology. *Innov. Food Technol.* **Nov**: 25–27.
854. Traynor IM, Crooks SRH, Bowers J, Elliott CT. 2003. Detection of multi-β-agonist residues in liver matrix by use of a surface plasma resonance biosensor. *Anal. Chim. Acta* **483**: 187–191.
855. Tüdos AJ, Lucas-van den Bos ER, Stigter ECA. 2003. Rapid surface plasmon resonance-based inhibition assay of deoxynivalenol. *J. Agric. Food Chem.* **51**: 5843–5848.
856. van der Gaag B, Spath S, Dietrich H, Stigter E, Boonzaaijer G, van Osenbruggen T, Koopal K. 2003. Biosensors and multiple mycotoxin analysis. *Food Control* **14**: 251–254.

Mass spectrometry.

857. Burns KL, May SW. 2003. Separation methods applicable to the evaluation of enzyme-inhibitor and enzyme-substrate interactions. *J. Chromatogr. B* **797**: 175–190.
858. Kikuchi J, Furukawa Y, Hayashi N. 2003. Identification of novel p53-binding proteins by biomolecular interaction analysis combined with tandem mass spectrometry. *Mol. Biotechnol.* **23**: 203–212.
859. Lopez F, Pichereaux C, Burlet-Schiltz O, Pradayrol L, Monsarrat B, Estève JP. 2003. Improved sensitivity of biomolecular interaction analysis mass spectrometry for the identification of interacting molecules. *Proteomics* **3**: 402–412.
860. Nedelkov D, Nelson RW. 2003. Delineating protein-protein interactions via biomolecular interaction analysis-mass spectrometry. *J. Mol. Recognit.* **16**: 9–14.
861. Nedelkov D, Nelson RW. 2003. Design and use of multi-affinity surfaces in biomolecular interaction analysis-mass spectrometry (BIA/MS): a step toward the design of SPR/MS arrays. *J. Mol. Recognit.* **16**: 15–19.
862. Nedelkov D, Nelson RW. 2003. Detection of staphylococcal enterotoxin B via biomolecular interaction analysis mass spectrometry. *Appl. Environ. Microbiol.* **69**: 5212–5215.
863. Nedelkov D, Nelson RW, Kiernan UA, Niederkofler EE, Tubbs KA. 2003. Detection of bound and free IGF-1 and IGF-2 in human plasma via biomolecular interaction analysis mass spectrometry. *FEBS Lett.* **536**: 130–134.

Other applications.

864. Bokken GCAM, Corbee RJ, van Knapen F, Bergwerff AA. 2003. Immunochemical detection of *Salmonella* group B, D and E using an optical surface plasmon resonance biosensor. *FEMS Microbiol. Lett.* **222**: 75–82.
865. Choe W-s, Clemmitt RH, Chase HA, Middelberg APJ. 2003. Coupling of chemical extraction and expanded-bed adsorption for simplified inclusion-body processing: optimization using surface plasmon resonance. *Biotechnol. Bioeng.* **81**: 221–232.
866. Dreja H, Gros L, Villard S, Bachrach E, Oates A, Granier C, Chardes T, Mani J-C, Piechaczyk, Pelegrin M. 2003. Monoclonal antibody 667 recognizes the variable region A motif of the ecotropic retrovirus CasBrE envelope glycoprotein and inhibits Env binding to the viral receptor. *J. Virol.* **77**: 10984–10993.
867. Hammar L, Markarian S, Haag L, Lankinen H, Salmi A, Cheng RH. 2003. Prefusion rearrangements resulting in fusion peptide exposure in Semliki Forest virus. *J. Biol. Chem.* **278**: 7189–7198.
868. Hardy SA, Dimmock NJ. 2003. Valency of antibody binding to enveloped virus particles as determined by surface plasmon resonance. *J. Virol.* **77**: 1649–1652.
869. Hira T, Hara H, Tomita F, Aoyama Y. 2003. Casein binds to the cell membrane and induces intracellular calcium signal in the enteroendocrine cell: a brief communication. *Exp. Biol. Med.* **228**: 850–854.
870. Jung K-H, Trivedi VD, Spudich JL. 2003. Demonstration of a sensory rhodopsin in eubacteria. *Mol. Microbiol.* **47**: 1513–1522.
871. Kawashima M, Hanada N, Hamada T, Tagami J, Senpuku H. 2003. Real-time interaction of oral streptococci with human salivary components. *Oral Microbiol. Immunol.* **18**: 220–225.
872. Kumar A, Kamihara M, Galaev IY, Iijima S, Mattiasson B. 2003. Binding of Cu(II)-poly(*N*-isopropylacrylamide/vinylimidazole) copolymer to histidine-tagged protein: a surface plasmon resonance study. *Langmuir* **19**: 865–871.
873. McKay DB, Prucha M, Reineke W, Timmis KN, Pieper DH. 2003. Substrate specificity and expression of three 2,3-dihydrobiphenyl 1,2-dioxygenases from *Rhodococcus globerulus* strain P6. *J. Bacteriol.* **185**: 2944–2951.
874. Mendelsohn JD, Yang SY, Hiller J, Hochbaum AI, Rubner MF. 2003. Rational design of cytophilic and cytophobic polyelectrolyte multilayer thin films. *Biomacromolecules* **4**: 96–106.
875. Nakano K, Tadagaki K, Isegawa Y, Aye MM, Zou P, Yamanishi K. 2003. Human herpesvirus 7 open reading frame U12 encodes a functional β-chemokine receptor. *J. Virol.* **77**: 8108–8115.
876. Nishi T, Hara H, Tomita F. 2003. Soybean β-conglycinin peptone suppresses food intake and gastric emptying by increasing plasma cholecystokinin levels in rats. *J. Nutr.* **133**: 35–357.
877. Pantarotto D, Partidos CD, Graff R, Hoebeke J, Briand J-P, Prato M, Bianco A. 2003. Synthesis, structural characterization, and immunological properties of carbon nanotubes functionalized with peptides. *J. Am. Chem. Soc.* **125**: 6160–6164.
878. Park J-Y, Lansbury PT Jr. 2003. β-Synuclein inhibits formation of α-synuclein protofibrils: a possible therapeutic strategy against Parkinson's disease. *Biochemistry* **42**: 3696–3700.
879. Rhyner C, Weichel M, Hübner P, Achatz G, Blaser K. 2003. Phage display of human antibodies from a patient suffering from coeliac disease and selection of isotype-specific scFV against gliadin. *Immunology* **110**: 269–274.
880. Yano K, Yoshino T, Shionoya M, Sawata SY, Ikebukuro K, Karube I. 2003. Preparation of a whole genome phage library using fragmented *Escherichia coli* genome and its characterization of protein binding properties by surface plasmon resonance. *Biosens. Bioelectron.* **18**: 1201–1207.

Affinity Sensors

881. Acharya S, Foster PL, Brooks P, Fishel R. 2003. The coordinated functions of the *E. coli* MutS and MutL proteins in mismatch repair. *Mol. Cell* **12**: 233–246.
882. Anikeeva N, Lebedeva T, Krogsgaard M, Tetin SY, Martinez-Hackert E, Kalams SA, Davis MM, Sykulev Y. 2003. Distinct molecular mechanisms account for the specificity of two different T-cell receptors. *Biochemistry* **42**: 4709–4716.
883. Anikeeva N, Lebedeva T, Sumaroka M, Kalams SA, Sykulev Y. 2003. Soluble HIV-specific T cell receptor: expression, purification and analysis of the specificity. *J. Immunol. Meth.* **277**: 75–86.
884. Bananis E, Murray JW, Stockert RJ, Satir P, Wolkoff AW. 2003. Regulation of early endocytic vesicle motility and fission in a reconstituted system. *J. Cell Sci.* **116**: 2749–2761.
885. Battaglia A, Bertucci C, Bombardelli E, Cimitan S, Guerrini A, Morazzoni P, Riva A. 2003. Synthesis and HSA binding characterisation of the water soluble 7-succinylpaclitaxel. *Eur. J. Med. Chem.* **38**: 383–389.
886. Bertucci C, Cimitan S, Menotti L. 2003. Optical biosensor analysis in studying herpes simplex virus glycoprotein D binding to target nectin1 receptor. *J. Pharm. Biomed. Anal.* **32**: 697–706.
887. Bertucci C, Cimitan S. 2003. Rapid screening of small ligand affinity to human serum albumin by an optical biosensor. *J. Pharm. Biomed. Anal.* **32**: 707–714.
888. Bertucci C, Cimitan S. 2003. Inhibition of drug binding to human serum albumin by cholecystographic agents. *Il Farmaco* **58**: 901–908.
889. Castelli ME, Cauerhff A, Amongero M, Soncini FC, Véscovi EG. 2003. The H box-harboring domain is key to the function of the *Salmonella enterica* PhoQ Mg^{2+}-sensor in the recognition of its partner PhoP. *J. Biol. Chem.* **278**: 23579–23585.
890. Cerutti ML, Centeno JM, de Prat-Gay G, Goldbaum FA. 2003. Antibody response to a viral transcriptional regulator. *FEBS Lett.* **534**: 202–206.
891. Dmitriev DA, Massino YS, Segal OL. 2003. Kinetic analysis of interaction between bispecific monoclonal antibodies and immobilized antigens using a resonant mirror biosensor. *J. Immunol. Meth.* **280**: 183–202.
892. Fang J, Fang L, Wang D-B, Chen C-Q. 2003. Studies on interaction between hTNF-α and its two receptors with expressed hsTR55-preS1/hsTR75-preS1 fusion soluble receptors. *J. Immunol. Meth.* **274**: 199–207.
893. Huang TT, Sturgis J, Gomez R, Geng T, Bashir R, Bhunia AK, Robinson JP, Ladisch MR. 2003. Composite surface for blocking bacterial adsorption on protein biochips. *Biotechnol. Bioeng.* **81**: 618–624.
894. Huising MO, Guichelaar T, Hoek C, Verberg-van Kemenade BML, Flik G, Savelkoul HFJ, Rombout JHWM. 2003. Increased efficacy of immersion vaccination in fish with hyperosmotic pretreatment. *Vaccine* **21**: 4178–4193.
895. Hytönen VP, Laitinen OH, Grapputo A, Kettunen A, Savolainen J, Kalkkinen N, Marttila AT, Nordlund HR, Nyholm TKM, Paganelli G, Kulomaa MS. 2003. Characterization of poultry egg-white avidins and their potential as a tool in pretargeting cancer treatment. *Biochem. J.* **372**: 219–225.

896. Jelic M, Soll J, Schleiff E. 2003. Two Toc34 homologues with different properties. *Biochemistry* **42**: 5906–5916.
897. Kajimura M, Shimoyama M, Tsuyama S, Suzuki T, Kozaki S, Takenaka S, Tsubota K, Oguchi Y, Suematsu M. 2003. Visualization of gaseous monoxide reception by soluble guanylate cyclase in the rat retina. *FASEB J.* **10.1096**: fj.02–0359fje.
898. Kawakami H, Toma K. 2003. Lipid-conjugates of biotin and an avidin-binding peptide: synthesis and properties. In *Peptide Science 2002*, Yamada T (ed.). Japanese Peptide Society: Kyoto; 389–392.
899. Kawasaki T, Gouda MD, Sawasaki T, Takai K, Endo Y. 2003. Efficient synthesis of a disulfide-containing protein through a batch cell-free system from wheat germ. *Eur. J. Biochem.* **270**: 4780–4786.
900. Komatsu Y, Yukutake Y, Yoshida M. 2003. Four different clones of mouse anti-acetyllysine monoclonal antibodies having different recognition properties share a common immunoglobulin framework structure. *J. Immunol. Meth.* **272**: 161–175.
901. Laitinen OH, Nordlund HR, Hytönen VP, Uotila STH, Marttila AT, Savolainen J, Airenne KJ, Livnah O, Bayer EA, Wilchek M, Kulomaa MS. 2003. Rational design of an active avidin monomer. *J. Biol. Chem.* **278**: 4010–4014.
902. Lathrop AA, Jaradat ZW, Haley T, Bhunia AK. 2003. Characterization and application of a *Listeria monocytogenes* reactive monoclonal antibody C11E9 in a resonant mirror biosensor. *J. Immunol. Meth.* **281**: 119–128.
903. Malone ME, Appelqvist IAM, Norton IT. 2003. Oral behaviour of food hydrocolloids and emulsions. Part 1. Lubrication and deposition considerations. *Food Hydrocolloids* **17**: 763–773.
904. Mandon EC, Jiang Y, Gilmore R. 2003. Dual recognition of the ribosome and the signal recognition particle by the SRP receptor during protein targeting to the endoplasmic reticulum. *J. Cell Biol.* **162**: 575–585.
905. Matsuno H, Ishisaki A, Nakajima K, Okada K, Ueshima S, Matsuo O, Kozawa O. 2003. Lack of α2-antiplamsin promotes reendothelialization via over-release of VEGF after vascular injury in mice. *Blood* **102**: 3621–3628.
906. Matsuura E, Kobayashi K, Koike T, Shoenfeld Y, Khamashta MA, Hughes GRV. 2003. Oxidized low-density lipoprotein as a risk factor of thrombosis in antiphospholipid syndrome. *Lupus* **12**: 550–554.
907. Momynaliev KT, Govorun VM, Gnedenko O, Ivanov YD, Archakov AL. 2003. The use of the resonant mirror biosensor to detect point mutations, as demonstrated with synthetic oligonucleotides. *J. Mol. Recognit.* **16**: 1–8.
908. Nordlund HR, Laitinen OH, Uotila STH, Nyholm T, Hytönen VP, Slotte JP, Kulomaa MS. 2003. Enhancing the thermal stability of avidin. *J. Biol. Chem.* **278**: 2479–2483.
909. Nordlund HR, Hytönen VP, Laitinen OH, Uotila STH, Niskanen EA, Salovlainen J, Porkka E, Kulomaa MS. 2003. Introduction of histidine residues into avidin subunit interfaces allows pH-dependent regulation of quaternary structure and biotin binding. *FEBS Lett.* **555**: 449–454.
910. Oda Y, Senaha T, Matsuno Y, Nakajima K, Naka R, Kinoshita M, Honda E, Furuta I, Kakehi K. 2003. A new fungal lectin recognizing α(1–6)-linked fucose in the *N*-glycan. *J. Biol. Chem.* **278**: 32439–32447.
911. Schröder-Borm H, Willumeit R, Brandenburg K, Andrä J. 2003. Molecular basis for membrane selectivity of NK-2, a potent peptide antibiotic derived form NK-lysin. *Biochim. Biophys. Acta* **1612**: 164–171.
912. Schuster B, Kovaleva M, Sun Y, Regenhard P, Matthews V, Grötzinger J, Rose-John S, Kallen K-J. 2003. Signaling of human ciliary neurotrophic factor (CNTF) revisited. *J. Biol. Chem.* **278**: 9528–9535.
913. Selmane T, Schofield MJ, Nayak S, Du C, Hsieh P. 2003. Formation of a DNA mismatch repair complex mediated by ATP. *J. Mol. Biol.* **334**: 949–965.
914. Shao H, Cheng HY, Cook RG, Tweardy DJ. 2003. Identification and characterization of signal transducer and activator of transcription 3 recruitment sites within the epidermal growth factor receptor. *Cancer Res.* **63**: 3923–3930.
915. Skórko-Glonek J, Żurawa D, Tanfani F, Scirè A, Wawrzynów A, Narkiewicz J, Bertoli E, Lipińska B. 2003. The N-terminal region of HtrA heat shock protease from *Escherichia coli* is essential for stabilization of HtrA primary structure and maintaining of its oligomeric structure. *Biochim. Biophys. Acta* **1649**: 171–182.
916. Stein T, Heinzmann S, Kiesau P, Himmel B, Entian K-D. 2003. The *spa*-box for transcriptional activation of subtilin biosynthesis and immunity in *Bacillus subtilis*. *Mol. Microbiol.* **47**: 1627–1636.
917. Sundram V, Nanda JS, Rajagopal K, Dhar J, Chaudhary A, Sahni G. 2003. Domain truncation studies reveal that the streptokinase-plasmin activator complex utilizes long range protein-protein interactions with macromolecular substrate to maximize catalytic turnover. *J. Biol. Chem.* **278**: 30569–30577.
918. Tan PH, Manunta M, Ardjomand N, Xue SA, Larkin DF, Haskard DO, Taylor KM, George AJ. 2003. Antibody targeted gene transfer to endothelium. *J. Gene Med.* **5**: 311–323.
919. Tsurupa G, Ho-Tin-Noé B, Anglés-Cano E, Medved L. 2003. Identification and characterization of novel Lys-independent apolipoprotein(a)-binding sites within fibrin(ogen) αC-domains. *J. Biol. Chem.* **278**: 37154–37159.
920. Waller KL, Nunomura W, An X, Cookie BM, Mohandas N, Coppel RL. 2003. Mature parasite-infected erythrocyte surface antigen (MESA) of *Plasmodium falciparum* binds to the 30-kDa domain of protein 4.1 in malaria-infected red blood cells. *Blood* **102**: 1911–1914.
921. Watkins NA, Du LM, Scott JP, Ouwehand WH, Hillery CA. 2003. Single-chain antibody fragments derived from a human synthetic phage-display library bind thrombospondin and inhibit sickle cell adhesion. *Blood* **102**: 718–724.
922. Wei J-Y, Liu X, Song D-Q, Bu L-S, Hu X, Mu Y, Zhang H-Q, Luo G-M, Zhang G-Z, Ding J-H, Wang W-Z, Jin Q-H. 2003. Preparation of anti-cardiac troponin I monoclonal antibodies and their characterization with surface plasmon resonance biosensor. *Chem. Res. Chin. Univ.* **19**: 183–189.
923. Wu X-F, Xu Y-X, Shen G-X, Kamei K, Takano R, Hara S. 2003. Surface plasmon resonance analysis to evaluate the importance of heparin sulfate groups binding with human aFGF and bFGF. *J. Zhejiang Univ. Sci.* **4**: 86–94.
924. Yu X, Wang Q-Y, Guo Y, Dolmer K, Young JAT, Gettins PGW, Rong L. 2003. Kinetic analysis of binding interactions between the subgroup A Rous sarcoma virus glycoprotein SU and its cognate receptor Tva: calcium is not required for ligand binding. *J. Virol.* **77**: 7517–7526.
925. Zhang H, Wang G, Ding Y, Wang Z, Barraclough R, Rudland PS, Fernig DG, Rao Z. 2003. The crystal structure at 2 Å resolution of the Ca^{2+}-binding protein S100P. *J. Mol. Biol.* **325**: 785–794.

Texas Instruments

926. Celer V, Blažek D, Navrátilová I, Sktádal P, Blacklaws B, Bujdoso R. 2003. Recombinant single-chain Fv antibodies that recognize the p25 protein of the Maedi-Visna virus. *Folia Microbiol.* **48**: 435–440.
927. Chinowsky TM, Quinn JG, Bartholomew DU, Kaiser R, Elkind JL. 2003. Performance of the Spreeta 2000 integrated surface plasmon resonance affinity sensor. *Sensors Actuat. B* **91**: 266–274.
928. Dukh M, Šaman D, Lang K, Pouzar V, Černý I, Drašar P, Král V. 2003. Steroid-porphyrin conjugate for saccharide sensing in protic media. *Org. Biomol. Chem.* **1**: 3458–3463.
929. Ishihara T, Arakawa T. 2003. Detection of cytochrome C by means of surface plasmon resonance sensor. *Sensors Actuat. B* **91**: 262–265.
930. Matějka P, Hrubý P, Volka K. 2003. Surface plasmon resonance and Raman scattering effects studied for layers deposited on Spreeta sensors. *Anal. Bioanal. Chem.* **375**: 1240–1245.
931. Miyamoto T, Shimizu Y, Kobayashi H, Honjoh K-i, Iio M. 2003. Studies of collagen binding with immobilized *Salmonella enteritidis* and inhibition with synthetic and naturally occuring food additives by a surface plasmon resonance biosensor. *Sensors Mat.* **15**: 453–466.
932. Naimushin AN, Soelberg SD, Bartholomew DU, Elkind JL, Furlong CE. 2003. A portable surface plasmon resonance (SPR) sensor system with temperature regulation. *Sensors Actuat. B* **96**: 253–260.

933. Navrátilová I, Skládal P. 2003. Immunosensor for the measurement of human serum albumin in urine based on the Spreeta surface plasmon resonance sensor. *Supramol. Chem.* **15**: 109–115.
934. Sakai T, Torimaru A, Shinahara K, Miura N, Imato T, Toko K, Matsumoto K. 2003. Preparation of a polyclonal antibody and a bioassay for nitroaromatic compounds by an enzyme-linked immunosorbent assay technique and a surface plasmon resonance biosensor. *Sensors Mater.* **15**: 439–452.
935. Seong H, Choi W-M, Kim J-C, Thompson DH, Park K. 2003. Preparation of liposomes with glucose binding sites: liposomes containing di-branched amino acid derivatives. *Biomaterials* **24**: 4487–4493.
936. Whelan RJ, Zare RN. 2003. Surface plasmon resonance detection for capillary electrophoresis separations. *Anal. Chem.* **75**: 1542–1547.
937. Yi S-J, Yuk JS, Jung S-H, Zhavnerko GK, Kim Y-M, Ha K-S. 2003. Investigation of selective protein immobilization on charged protein array by wavelength interrogation-based SPR sensor. *Mol. Cells* **15**: 333–340.

DKK-TOA

938. Fujii E, Nakamura K, Sasaki S-I, Citterio D, Kurihara K, Suzuki K. 2003. Application of the absorption-based surface plasmon resonance principle to the determination of glucose using an enzyme reaction. *Instrum. Sci. Technol.* **31**: 343–356.
939. Gobi KV, Sasaki M, Shoyama Y, Miura N. 2003. Highly sensitive detection of polycyclic aromatic hydrocarbons (PAHs) and association constants of the interaction between PAHs and antibodies using surface plasmon resonance immunosensor. *Sensors Actuat. B* **89**: 137–143.
940. Miura N, Sasaki M, Gobi K, Kataoka C, Shoyama Y. 2003. Highly sensitive and selective surface plasmon resonance sensor for detection of sub-ppb levels of benzo[a]pyrene by indirect competitive immunoreaction method. *Biosens. Bioelectron.* **18**: 953–959.
941. Soh N, Tokuda T, Watanabe T, Mishima K, Imato T, Masadome T, Asano Y, Okutani S, Niwa O, Brown S. 2003. A surface plasmon resonance immunosensor for detecting a dioxin precursor using a gold binding polypeptide. *Talanta* **60**: 733–745
942. Soh N, Sonezaki M, Imato T. 2003. Modification of a thin gold film with boronic acid membrane and its application to a saccharide sensor based on surface plasmon resonance. *Electroanalysis* **15**: 1281–1290.
943. Soh N, Watanabe T, Asano Y, Imato T. 2003. Indirect competitive immunoassay for bisphenol A, based on surface plasmon resonance sensor. *Sensors Mat.* **15**: 423–438.

Optrel

944. Lee W, Oh B-K, Bae YM, Paek S-H, Lee WH, Choi J-W. 2003. Fabrication of self-assembled protein A monolayer and its application as an immunosensor. *Biosens. Bioelectron.* **19**: 185–192.
945. Oh B-K, Kim Y-K, Lee W, Bae YM, Lee WH, Choi J-W. 2003. Immunosensor for detection of *Legionella pneumophila* using surface plasmon resonance. *Biosens. Bioelectron.* **18**: 605–611.
946. Oh B-K, Lee W, Bae YM, Lee WH, Choi J-W. 2003. Surface plasmon resonance immunosensor for detection of Legionella pneumophila. *Biotech. Bioprocess. Engng.* **8**: 112–116.
947. Schoeler B, Poptoshev E, Caruso F. 2003. Growth of multilayer films of fixed and variable charge density polyelectrolytes: effect of mutual charge and secondary interactions. *Macromolecules* **36**: 5258–5264.

Windsor Scientific Ltd.

948. Dekker FJ, de Mol NJ, Bultinck P, Kemmink J, Hilbers HW, Liskamp RMJ. 2003. Role of solution conformation and flexibility of short peptide ligands that bind to the $p56^{lck}$ SH2 domain. *Bioorg. Med. Chem.* **11**: 941–949.
949. Dekker FJ, de Mol NJ, Fischer MJE, Liskamp RMJ. 2003. Amino propynyl benzoic acid building block in rigid spacers of divalent ligands binding to the Syk SH2 domains with equally high affinity as the natural ligand. *Bioorg. Med. Chem. Lett.* **13**: 1241–1244.
950. Dekker FJ, de Mol NJ, Fischer MJE, Kemmink J, Liskamp RMJ. 2003. Cyclic phosphopeptides for interference with Grb2 SH2 domain signal transduction prepared by ring-closing metathesis and phosphorylation. *Org. Biomol. Chem.* **1**: 3297–3303.
951. May LM, Russell DA. 2003. Novel determination of cadmium ions using an enzyme self-assembled monolayer with surface plasmon resonance. *Anal. Chim. Acta* **500**: 119–125.

Artificial Sensing Instruments

952. Bearinger JP, Vörös J, Hubbell JA, Textor M. 2003. Electrochemical optical waveguide lightmode spectroscopy (EC-OWLS): a pilot study using evanescent-field optical sensing under voltage control to monitor polycationic polymer adsorption onto indium tin oxide (ITO)-coated waveguide chips. *Biotechnol. Bioengng.* **82**: 465–473.
953. Brusatori MA, Tie Y, van Tassel PR. 2003. Protein adsorption kinetics under an applied electric field: an optical waveguide lightmode spectroscopy study. *Langmuir* **19**: 5089–5097.
954. Cottier K, Wiki M, Voirin G, Gao H, Kunz RE. 2003. Label-free highly sensitive detection of (small) molecules by wavelength interrogation of integrated optical chips. *Sensors Actuat. B* **91**: 241–251.

Eco Chemie

955. Praig VG, Hall EAH. 2003. Seeking connectivity between engineered proteins and transducers: connection for glutathione S-transferase fusion proteins on surface plasmon resonance devices. *Anal. Chim. Acta* **500**: 323–336.
956. Saha K, Bender F, Rasmusson A, Gizeli E. 2003. Probing the viscoelasticity and mass of a surface-bound protein layer with an acoustic waveguide device. *Langmuir* **19**: 1304–1311.
957. Saha K, Bender F, Gizeli E. 2003. Comparative study of IgG binding to proteins G and A: nonequilibrium kinetic and binding constant determination with the acoustic waveguide device. *Anal. Chem.* **75**: 835–842.

Nippon Laser and Electronics

958. Matsuda T, Nagase J, Ghoda A, Hirano Y, Kidoaki S, Nakayama Y. 2003. Phosphorylcholine-endcapped oligomer and block co-oligomer and surface biological reactivity. *Biomaterials* **24**: 4517–4527.
959. Taniwaki K, Hyakutake A, Aoki T, Yoshikawa M, Guiver MD, Robertson GP. 2003. Evaluation of the recognition ability of molecularly imprinted materials by surface plasmon resonance (SPR) spectroscopy. *Anal. Chim. Acta* **489**: 191–198.
960. Terada N, Morimoto M, Saimoto H, Okamoto Y, Minami S, Shigemasa Y. 2003. Regioselective synthesis and biological activity of oxidized chitosan derivatives. *Polymers Adv. Tech.* **14**: 40–51.

Analytical μ-systems

961. Zayats M, Kharitonov AB, Pogorelova S, Lioubashevski O, Katz E, Willner I. 2003. Probing photoelectrochemical processes in Au-CdS nanoparticle arrays by surface plasmon resonance: application for the detection of acetylcholine esterase inhibitors. *J. Am. Chem. Soc.* **125**: 16006–16014.
962. Zayats M, Pogorelova SP, Kharitonov AB, Lioubashevski O, Katz E, Willner I. 2003. Au nanoparticle-enhanced surface plasmon resonance sensing of biocatalytic transformations. *Chem. Eur. J.* **9**: 6108–6114.