

“Making us see science”

Visual images in popular science articles and science journalism

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The article explores how scientific research and scientists are represented visually in popular science and science journalism. It discusses communicative functions and cultural meanings of visual elements in science stories. Drawing on concepts from the visual grammar developed by Gunther Kress and Theo van Leeuwen, the author indicates how different kinds of modality are used to address the audience in popular science articles in *Scientific American* and *Illustrert Vitenskap* (a Scandinavian magazine). It is argued that the visual elements in popular scientific magazines are conventionally arranged in a manner coinciding with a pedagogical/educational intent typical of much popular science, taking the readers from a reality they are presumed to have experienced towards more abstract scientific knowledge. However, the two magazines analyzed differ markedly with respect to the audience competence that they implicate in their visual representations. The level of visual abstraction in *Scientific American* contributes to creating an identity for its audience as belonging to well-educated and advanced elites, as opposed to the images of *Illustrert Vitenskap*, where the emphasis is to a larger extent on a naturalistic coding. The author goes on to discuss how photographs, visual composition and verbal text work together in a multimodal rhetoric typical of many science and health stories in Norwegian newspapers.

Introduction

Illustrations representing spectacular explosions in the universe; diagrams attempting to show how nerve cells communicate; photographs depicting scientists in lab coats staring at test tubes: Such visual images occur quite frequently in popular science stories.

Mediated visual images do not simply accompany verbal texts. They actively organize meaning and invite to be interpreted in particular ways (Kress & van Leeuwen 1990, 1996, Veel 1998). However, little research has been done on how images create meaning in popular science and science journalism. This is a bit surprising considering the salient use of visual elements (such as graphical illustrations, photographs, drawings) not only in television programmes and popular science magazines like *Scientific American* and *New Scientist*, but also as a part of the specialized science pages or the science-related material in the news sections of daily newspapers.

This article explores how scientific research and scientists are represented visually in popular science and science journalism, and it discusses communicative functions and cultural meanings of visual elements conventionally used in science stories. I limit my analysis to samples from newspapers and popular science magazines. The journalistic articles mainly focus on research topics within medicine or the natural sciences.

I use both the term “popular science” and “science journalism” in order to encompass visual images represented in a popular science magazine like *Scientific American* (where most of the articles are written by scientists, not professional journalists) as well as images in articles about scientific research in newspapers. The latter are written by so-called independent journalists in my samples. However, the term “science journalism” is not limited to include only articles displaying a critical attitude or approach to their subject. Rather, I find it difficult to point out distinct visual features in journalistic articles that have a different approach to their subject than primarily attempting to popularize or explain developments in scientific research for an audience of non-professionals in the field reported on.

When I devote a relatively large part of the text to analyzing *Scientific American* (SA), it is because of the influence that the more than 150-year-old magazine has had on the formation of popular science, including its visual dimension. The Scandinavian magazine *Illustrert Vitenskap* (IV) has been somewhat influenced by SA visually. But IV has a markedly more populist orientation than SA, thus allowing for a fruitful comparative analysis of how visual images are presented to different readerships of popular science. I have also chosen to analyze images appearing in large newspapers in Norway (such as *Aftenposten* and *Verdens Gang*), an objective here being to shed light on how such media visually attempt to attract reader attention to stories about science among other kinds of news stories found in newspapers.

Many readers may link an expression like “visual images in the media” to photographs. However, theoretical and methodological introductions to reading images normally analyze several dimensions of visual presentation such as graphic illustrations, the composition of visual elements in layout, the level of abstraction in illustrations and how images and words work together rhetorically. I will also touch on such dimensions by using some of the insights and concepts provided by Gunther Kress and Theo van Leeuwen (1990, 1996) in their account of the grammar of visual design.

Questions for the study are: How are visual images applied in popular science magazine articles and newspaper articles presenting scientific issues and findings? What are possible meanings and functions of the images and their composition in such articles?

In the first part of the article, I particularly examine how visual modalities are used in information graphics (visual representations of information or knowledge) commonly found in popular science magazines. In the second part, I analyze visual representations of science in Norwegian newspapers. Here I do not only look at information graphics applied in science news, but also at formulaic photographic depictions of scientists and how such photographs work together with verbal text in a multimodal rhetoric found in science and health stories.

The analytical concepts discussed and applied in this study may hopefully contribute to what Norman Fairclough (1995: 201) calls “critical media literacy”, that is a critical awareness of media discourse in social processes. More specifically, it is hoped that media students and practitioners may be made aware of how visual images not only mediate science and facilitate our understanding of research-generated knowledge, but also reflect power relations between participants such as scientific researchers and audiences/readerships. Such awareness may again stimulate reflection on how science could be visualized differently in the media.

Visual communication is becoming more and more crucial in the domains of public communication, and it may be – as Kress and Van Leeuwen predict – that: “‘Visual literacy’ will begin to be a matter of survival, especially in the workplace” (1996: 3).

A narrative of nature?

One of few substantial contributions to understanding the use of images in popular science is provided by discourse analyst Greg Myers (1990). He analyzes the ways in which the narratives are constructed in some articles in scientific journals (*Science, Evolution, Hormones and Behaviour*) and in articles by the same authors on the same topics for more popular journals, *Scientific American* and *New Scientist*. According to Myers, the texts in the scientific journals create a *narrative of science*, whereas the popularizing articles present a *narrative of nature*. What is meant by these concepts? Basically, that the “scientific” texts emphasize and are organized according to processes and concepts of scientific research, and this is reflected in the syntax, vocabulary and illustrations. The focus of the popularizing articles, on the other hand, is on the object of research rather than the research activity. In journalistic representations of natural science, the narrative is chronological and organized around nature (plants or animals may be the subject). The syntax, vocabulary and illustrations emphasize the externality of nature to scientific practices.

Myers claims that the differences in the narratives of articles for professionals and those for popular audiences are even more apparent in the illustrations than in the verbal texts.

In one of the examples that Myers gives to support his assertion, he compares the visual representations in scientific journals with the use of images in a popularized account of the research in an article in SA. The articles are about biologist David Crew's research on the evolution of sexual behaviour and the systems that control reproduction in lizards and snakes. Crew's articles in scientific journals often have graphs showing cycles of various hormones. According to Greg Myers, the illustrations in the SA article, on the other hand, attract the readers' attention to the snakes themselves (to *nature*, in other words), rather than to the research as such. A painting of the snakes is reproduced on the cover of the magazine, and the introductory page of the article is dominated by a colour photograph of male snakes mating. The next pages feature a series of drawings of the mating behaviour of these garter snakes.

The four drawings of the snakes outline the stages in their mating behaviour and thus provide a narrative of nature for the article (Fig. 1). See the appendix for the figures referred to.

The article also features graphs of hormonal cycles, illustrating central findings of Crew's studies (Fig. 2). The way Myers sees it, SA at each stage includes a little picture showing sperm in the testicles or displaying little snakes growing in the eggs and then hatching. These are illustrations attempting to visualize for the non-specialist reader what the stages mean. And Myers claims that these illustrations "help the reader to focus attention on the organism rather than on the concept of cycles, or on the measurement of hormonal levels and the gonadal sizes that are the data reported here" (Myers 1990: 161). The same effect is not brought about by the "more stylized" sorts of graphs used in scientific journals such as the one in *Hormones and Behavior* (Fig. 3).

Myers' suggestion of a radical difference in the way the graphs in the texts of the professional and popular articles function is not particularly convincing. By visual means, SA communicates

the concept of hormonal cycles rather than drawing attention to the organisms as such. But the graph in this magazine illustrates this in a pedagogical manner by *also* including illustrations of the organisms, in this case the snakes. The fact that the popular scientific magazine includes such representations does not necessarily imply that attention is drawn away from the scientific concepts, but rather that they aid our understanding of them by also showing explicitly the natural objects.

Naturalistic and scientific modality

In order to acquire a better understanding of the way images communicate meaning in different kinds of popular science articles, I find it useful to apply some of the concepts that Kress and van Leeuwen (1996) provide in their account of the grammar of visual design. This goes particularly for their concept of *modality*. The term ‘modality’ is from linguistics and refers to the truth value or credibility of statements about the world. In different social groupings there is a tendency that different expressions and criteria develop in order to decide what is more or less credible, true or real.

Kress and van Leeuwen accentuate some main modalities in our culture, or more precisely some ‘coding orientations’, which are sets of abstract principles that inform the way in which verbal texts and images are coded by specific social groups or within specific social contexts. Two of the main categories can be termed, with discourse analyst Per Ledin’s formulations (Ledin 2000), ‘naturalistic’ and ‘scientific’ modality. In naturalistic modality, the visual representation of the world is based on norms stating that we observe the true world with *the naked eye*, whereas visual representation in scientific modality is based on norms according to which the truth is *abstract*: It is not accessible by close and spontaneous experience of reality and must be established by scientific principles. Briefly, the two kinds of modality can be expressed in the following way:

A naturalistic modality: A visualization coding the world according to our everyday sensory experiences, as we per-

ceive it with the naked eye. The modality is marked by elements such as depth, detail, background and light being included in the representation.

A scientific modality: A visualization that does not stop at our everyday perception of the world, but probes beyond the visual appearance of things towards what is found 'below the surface', towards the general and principal. The modality is characterized by a suppression of elements such as depth, detail, background, light and shadow.

(The descriptions are from Ledin 1997: 49, my translation)

Different modalities address the audience in different ways. On the one hand, we can talk about visual elements relating to "what we see". Colour photographs often code reality in a way that relates to the viewers' everyday sensory experiences, at least we have a tendency to understand them in such a way. On the other hand, visual elements that relate to "what we know" present this knowledge at a greater distance from our everyday experiences. For example, graphs are conventionally regarded as expressing a more abstract or scientific modality. They are a kind of visual representation that omits background, depth and other dimensions conventionally contributing to an everyday spontaneous coding of reality.

Such categories of modality are not absolute, they are found in mixed forms. However, different social groups and institutions will accentuate different modalities depending on the context of communication. For instance, elite groups in society are more prone to use abstract visual modalities. One should not forget how the ability to produce or read signs grounded in this coding is a mark of social distinction, of being an 'educated person'.

Modality and composition in magazines

Popular science magazines typically apply mixed forms of modality in their visual presentations. This is characteristic of an elite-oriented magazine such as *Scientific American* as well as

the Scandinavian magazine *Illustrert Vitenskap* (“Illustrated Science”), which markets itself as “The Nordic countries’ largest magazine on nature, science and technology”. In popular science magazines where the intention to a large extent is to convey “new” scientific findings or insights and at the same time create some understanding of scientific concepts and ways of reasoning (however different their ambitions in this respect), it is characteristic that the articles are presented as a mixture of verbal text and graphs and images – whether they are photographs or more or less naturalistic illustrations by drawings or paintings.

Scientific American

Let’s have a look at SA first. Glancing through any recent edition, one is struck by the visual presentations of the magazine. Undoubtedly, they are eye-catching, even flashy when compared to the sparse line drawings of specialist journals – that is, if these journals include any illustrations at all.

But it is also a distinguishing trait of the articles in SA that the visual expressions mix different modalities. Very often, the visual layout of an article combines representations of “what we see” and of “what we know”. As in the visualization of how the earth’s carbon cycle can influence global climate and the role a plant-like organism plays in this process (Fig. 4).

The images of nature with mountains, the ocean, clouds, the sky, a volcano *and* the factory pipe represent ‘what we see’, whereas the arrows in the landscape that connect different elements in the picture accompanied by words and figures represent ‘what we know’, or at least what science has contributed to our knowledge about transport and causal connections in this cycle.

When different visual elements are organised in articles that cover several pages, they tend to follow a pattern where a naturalistic orientation precedes a scientific orientation. Characteristically, a naturalistic modality dominates the visual expression on the opening pages of the articles (together with the head and the lead), whereas more of a scientific or an abstract modality occurs further on in the article. This is illustrated by an

article about a parasite bacterium with the ability to change the sex of or eliminate its hosts.

The story's layout begins with images (Fig. 5) of what we can see and relate to, at first a butterfly threatened by the parasite (the butterfly being beautiful and eye-catching – together with the visually salient word “sex” in the headline). Photographs of other insects influenced by the bacterium follow (Fig. 6), before the last composition of images covering two pages presents a more abstract graphic visualization of the parasite's adaptive tactics (Fig. 7).

Visually, there is in other words a movement from what is known, that is from images familiar to the reader, to more abstract representations – to what appears to be new information to the uninitiated in the field of research. In several of the larger graphic illustrations in SA, the visual elements are also distributed along a horizontal axis in such a way that those placed on the left are presented as *given* and the ones on the right as *new*. This is in accordance with a rule in Kress and van Leeuwen's grammar of visual design. This rule can be understood as one of the codes of spatial composition of visual elements, at least in western cultures. In the upper part of the illustration of how a particular kind of cells orchestrates the immune response against invaders (Fig. 8), the given (the human body) is typically placed to the left. The level of visual abstraction increases further to the right along a horizontal axis.

To a large extent, the images in a magazine like SA are arranged – together with the text – in a way that attempts to take the reader from a world she has experienced and is familiar with to a reality of more abstract scientific knowledge. This kind of movement is similar to what Robert Veil (1998) has observed as an effect of visual images in environmentalist texts for students.

The manner of switching between naturalistic and abstract visual modalities seems to have a kind of verbal parallel in what I have elsewhere characterized as a ‘semi-narrative’ form displayed in a lot of science journalism (this also applies to SA, see Hornmoen, Meyer & Sylwan 2006). A typical way of structuring these texts is to have narrative parts (preferably in the opening and at the end of an article) alternate with parts devoted to ex-

position. Whether they focus on the actions or the behaviour of human beings or other organisms, a main objective of the narrative parts is to create reader identification, whereas the expository parts describe, elucidate and discuss processes and findings of the research presented in greater detail.

But although many of the visual compositions undeniably have a pedagogical function, I emphasize that one finds exceptions to the rule of the given placed to the left and the new to the right in the double-paged compositions of this magazine. Graphs with a marked abstract modality often appear in the left part of the compositions. And it is certainly not always the case that graphic illustrations and diagrams explicitly offer the reader something she has “already seen” as a point of entrance to visual abstractions of the research presented. For instance, the illustration of a vaccine strategy against AIDS (Fig. 9) is at a considerable semiotic distance from what we see with ‘the naked eye’, in spite of some outlines of an arm and a syringe.

Illustrations such as this one signal the kind of audience the magazine addresses. To a larger extent than many other popular science magazines, the compositions of SA do take the readers’ interest and competence in abstract visual codes for granted. The abstractions in the magazine’s graphic illustrations also have a verbal parallel in a relatively frequent use of a specialized vocabulary in the articles. The specialized words and the abstract visualizations mark a ‘differentness’ in relation to both the everyday language and the more naturalistic images used. This ‘differentness’ does not only signal that the version of reality which this language presents (or creates) is ‘alien’ compared to the version presented by everyday language and naturalistic images. When such different signs are included to the extent that they are in SA, they also contribute to creating an identity for its readers as belonging to a well-educated and advanced socio-cultural elite.

Comparing Scientific American with Illustrert Vitenskap

In a rather clear contrast to SA, the visual compositions in IV signal that this magazine addresses a broader audience than elite groups in society. Although a curiosity about science to some extent is expected from the reader, the magazine hardly

presupposes a special competence in abstract visual codes. That is not to say that the influence of a magazine like SA cannot be traced in this magazine's layout of text, images and graphs.

However, a naturalistic orientation is more dominant in IV. Differences between the two magazines stand out in their cover illustrations. Whereas SA seldom has naturalistic representations of human beings on its covers, such images as well as other motifs with a naturalistic modality commonly appear on the cover of IV. The covers of the two magazines issued in September 2003 (Fig. 10), both of them with neuroscience as their main story, hint at the influence of SA on IV. But the covers also indicate disparities in their visual aesthetics and ways of addressing the public. In IV, the human face is salient beneath the image of the brain. The glare of the eye can be interpreted as underscoring the mysteries in the headline ('hjernens mysterier' can be translated into 'the mysteries of the brain'). But the direct way of addressing the viewer also signals that this is a topic that concerns 'you', in other words the onlooker (or potential reader of the magazine).

The cover of SA to a larger extent appears as something to observe. When the human figure's head is depicted in *profile*, the viewer is positioned at a greater distance from it than from the motif of IV. The composition as a whole also requires more of an active interpretative role from the viewer in order for it to make sense at some level.

Moreover, the layout in IV more consistently follows a pattern where the naturalistic is positioned to the left, and illustrations with a somewhat more abstract coding are placed to the right. In a story about stress (Fig. 11), there is a visual appeal to the reader's recognition on the left of the two-page layout, while on the right there is a graph illustrating one's ability to perform and one's level of stress as well as the "new" information that research has generated. The graphic illustrations are less complex in this magazine, with a visualization that rarely invites the reader to reflect on the research being presented. A case in point is the layout for a story about an allegedly increasing IQ in the population (Fig. 12), the images here accompanying the headline's assertion "We are getting wiser and wiser". It is a kind of

visual aesthetic that to a larger degree than SA's illustrations contributes to creating an image of scientific research as an activity about discovering more or less certain connections, or 'facts', in the world.

Illustrations in the Norwegian press

I now take a closer look at the visual dimension in journalism about science and research issues in the Norwegian press.

The press in Norway does not have an extensive specialized coverage of science and scientifically related issues (Eide & Ot-tosen 1994, Hornmoen 1999). Apart from some specialized radio and TV programmes and a few specialized pages in the newspapers, science and research issues typically appear as a part of the general news coverage or as a part of other areas, for instance the coverage of health issues. I emphasize that the press uses scientists as so-called expert sources commenting on news events just as much as it lets them speak about scientific research as such. The activity of representing comments by experts hardly qualifies as 'science journalism'. But it is worth mentioning that when photographs of commenting experts are included in the story's layout, it is not unusual to arrange a setting that visually underscores their status as scientific experts, whether this is achieved by the photo capturing them in front of shelves upon shelves with books or in technologically authoritative laboratory settings (Fig. 13). Such illustrations serve to strengthen the credibility of the portrayed expert's message as well as strengthening the impression of the journalistic story as being a truthful representation of reality.

But quite often, one also sees visual compositions that are inspired by the popular science genre as it appears in magazines. The ambition is then, apparently, to convey scientific research findings or to situate news events within a research-based frame of understanding. For newspapers with sufficient financial resources, photographs or other kinds of illustrations with a marked naturalistic orientation are supplemented by more or less sophisticated graphs. Accompanying an article in the newspaper *Aftenposten* about Mars being closer to the earth than it has

been for a long time, we can see the typical mix of modalities (Fig. 14). Here there is an illustration of the Neanderthals to the left and a more abstract modality to the right. However, the abstraction is not at the level characteristic of the graphs of Scientific American – the audience of the newspaper clearly being considered to be broader than that of SA.

Tendencies in the visualization of science issues in the press can be considered in relation to how these issues are represented and framed in words. In my own study of the science coverage in Norwegian daily newspapers (Hornmoen 2003), I identify some traits typical of how scientific research is represented in journalistic texts. Use of language and frames emphasizing the uniqueness and the awesome qualities of the phenomenon or issue exposed is widespread, whether this is a technological innovation as a result of research or the research activity itself or what is “uncovered” or “revealed” by this activity. Related to this is a preoccupation with findings or discoveries. In addition, many articles focus on the potential utility and the kind of application that can result from research.

Reports on so-called ‘sensational’ or ‘unique’ scientific discoveries have a long tradition in journalistic coverage of science. American journalists have called this “gee-whiz-reporting” or “breathless discovery stories” (see Blum and Knudson 1997). The visual correlate to this journalism is spectacular illustrations of what scientific research has ‘revealed’ or science-based technology has generated, so that the illustrations indirectly constitute a tribute to science or to the technology that has enabled them (Fig. 15, Fig. 16). Impressive motifs of celestial bodies, planets and stars repeatedly occur in articles about astronomy. However, the possibility of creating flashy images such as the SA illustration of explosions in the universe (Fig. 17) is more limited in newspapers than in magazines.

Displaying the value of science

Such spectacular illustrations are visual expressions of what rhetorician Jeanne Fahnestock (1993) has termed the *wonder appeals* characteristic of science journalism. Her viewpoint is that journalists try to reach and engage readers by being clear

in their claims about the value of the scientific discoveries they report on. One way of doing that is praising or ‘celebrating’ the findings. In my view, spectacular illustrations of the kind mentioned invite the reader, or rather the viewer, to strike a position where she looks up to the phenomenon or object represented in humble admiration of what scientific research is capable of uncovering and technology can manage to produce.

More prosaic are the articles in health journalism presenting research with possible consequences for our health. But the illustrations of such stories also try to be explicit about the value of the research reported on. For an audience of non-experts, a recognized value in this area is how the research leads to further benefits, how it can be used to improve people’s health. This kind of value requires the efforts of photographers and illustrators to make it visible in a newspaper layout. For instance, the visual composition in an article (Fig. 18) tries to establish a connection between the photograph and the graphic illustration right beneath it, so that the science-based vaccine method described appears to be relevant and important to the audience. In the photo, the researcher depicted (the researcher in a white lab coat, one notes) is looking at the mouse and the syringe, his glance in this way forming a so-called *vector* – in other words an imagined line, here emanating from the researcher’s eyes. The direction of his glance leads the reader’s glance towards the new vaccine which is the topic of the article (the article’s headline may be translated into “New Norwegian vaccine method: can help against HIV and cancer”). For the reader, an image of a needle pricked into a laboratory mouse is hardly a striking expression of the vaccine’s potential applicatory value. But in the total visual composition, the syringe also forms a vector down towards the graphic illustration’s motif of a human arm which the needle is put into, this under the subtitle “This is how the new vaccine method works”.

The more abstract modality that dominates the graphic illustration may presumably function – together with several specialized words in text beneath it – to convince the reader about the utility of the vaccine method. Words that are used here may give the reader the impression that ‘the authoritative voice of sci-

ence' is speaking. The irony is that the article's main text discloses that this vaccine method has still not been tested on human beings. In their eagerness to visualize the utility of the method, the illustrators end up promising more about its potential for application than what is reasonable based on the vaccine experiments. However, this kind of visualization is barely unfortunate for research groups seeking publicity and access to research funding through the media.

Selling science through images

Selling science through the media has become a main objective for many public relations professionals as well as researchers in scientific institutions (Nelkin 1995). Quite a lot of the science stories in the Norwegian press also suggest that journalists, photographers and layout professionals readily promote different types of research and try to create a public appreciation of scientists' need for more funding. Sometimes the mission on behalf of science can take on a form of argumentation strikingly similar to the rhetoric of advertising. A main goal of advertising is to set the recipients of a message in a mood that makes them receptive to the argumentation of the 'sender' of the message. A typical strategy is to oppose negative attitudes that one assumes the audience might have and open up to the positive sides of the product or the service. ("You may have been told that Fiat corodes fast. You can forget that. We have now developed ...").

A similar strategy can be traced in the *Aftenposten* story about Norwegian biotechnology "lagging behind" (Fig. 19). Particularly interesting here is how the photographs, the visual composition and the text work together in order to convince the reader about the necessity of investing more money in Norwegian biotechnology. A picture of a mouse with human ears – an image likely to arouse feelings of disgust – is positioned on the top left hand side of the page beside a large photograph of a bioengineer seeing "the future" and "the possibilities" of the industry. In the text beneath the photo of the mouse, the research leader in a biotech company is cited as saying that he understands that people regard images like the 'mouse with the human ear' as grotesque, but he also points out that he does not

reckon that ‘cultivation of ears’ will become a major research trend in biotechnology. The lead and other parts of the text follow up by presenting common objections that people have and then let the leader argue against these or assert that “biotechnology is essentially not controversial”. In this way, he is allowed to make way for the message: Norway is unfortunately lagging behind in this field, but it can become a great growth industry if these companies are given “the same possibilities to develop as in other European countries”. At the bottom of the page, there is another picture that in contrast to the image of the mouse indirectly argues ethically in favour of this field of research. The illustration text tells the reader that what we see is “nice technology”, a so-called “technomouse” that the participants in the picture are “caressing”, a machine that, according to the text, will “spare the lives of 3,000 laboratory mice every year”.

If the illustrations together with the text in this story attempt to put a so-called media-created image (the mouse with the ear signifying the scary biotechnology) to death, I am personally more struck by how the large picture contributes to maintain a cultural stereotype. The picture of the researcher glancing at the test tube and its content has become a visual cliché in newspapers. The image is especially used to illustrate stories about assumed developments within genetic research and biotechnology. This image is in many ways a continuation and transformation of a traditional cultural stereotype, namely *the fortune teller with the crystal ball*. The difference is that it is the researcher who is granted the ability to see the possibilities, to foresee the future.

Apart from creating cultural prejudices such as “scientific research is something that goes on in laboratories and is carried out by people with test tubes and white coats”, I notice how this and other pictures with a similar motif (Fig. 20, Fig. 21), tend to construct a certain viewer position by the use of angles in the photograph. As Ledin (1997) notes, when the angle makes the viewer ‘look up’ towards the depicted, this gives the participants in the picture a symbolic power over the onlooker. Furthermore, he notes how images with participants depicted in profile situate the viewer at a distance where she is not expected to engage directly with them, unlike a depiction ‘from the front’ – face to face.

In my three examples of ‘researchers with tubes’, two of them are depicted in profile, whereas the angle in all the photos are from below and up towards the researcher (although in varying degrees). The scientists are looking upwards at the test tubes (or the glass), so that the viewer’s eyes are led to fixate what can be considered both an instrument in (the tubes) and a product of research (the content of the tubes) as if to signal: herein lie the possibilities, or herein is the solution, whether it is the solution to a lack of industrial innovation in Norway or, in a broader sense, the solution to the problems of mankind or the world’s crises. These are images that create a distance in relation to their audience. To me, the images also transmit something beyond their overt message (the message that in this field of research there are vast possibilities). At another level, the pictures tell me that these possibilities are something that is reserved for these scientist experts, something they deal with. Even though their predictions and results to some extent will concern me, they are not something that I am an implicated participant in, something that I – or “the readers” in a wider sense – can join in and contribute to creating conditions for. The images create a distance to their audience in the same way as standardized science news formulations such as “scientists have shown” and the frequent references to “unique” scientific discoveries. The many images of researchers in white coats in science journalism work in the same way as the visualizations of ‘spectacular’ or ‘awesome’ objects of scientific research do. Above all, they invite the audience to look up to scientists and science in deep admiration and respect.

Concluding remarks

Let me sum up tendencies in how visual images are used in popular science and science journalism. A characteristic trait in popular science magazines is that they alternate between graphs, photographs, other types of illustrations and verbal texts. The illustrations of the stories often switch between a naturalistic modality and a more abstract modality in a way that can take the reader from a reality she is familiar with towards a reality con-

sisting of more abstract scientific knowledge. However, there can be marked differences in the way a magazine like *Scientific American* and one like *Illustrert Vitenskap* addresses its readers. Graphic illustrations are less complex in IV than in SA. They hardly invite the reader to reflect on the represented research, which typically appears as an activity that discovers ‘facts of the world’. In contrast, the more complex graphics in SA to a larger extent draw attention to the processes and concepts of science. Differences in the levels of visual abstraction indicate the two magazines’ differing views of their readerships. In contrast to IV, SA creates an elite identity for its readers.

In major Norwegian newspapers, one also finds several examples of a visual mixture of naturalistic and abstract modalities. Moreover, visual motifs and compositions may be marked by how the articles highlight so-called “unique” research findings or emphasize the utility of the research. Whether they include spectacular illustrations of what new research has ‘revealed’ or pictures of researchers in white coats lifting test tubes, such popular science clichés invite their audience to look up to scientists and their activities in admiration. Often, the visual compositions are designed in a way that makes them suited to convince readers of the vast possibilities of the research reported on. This suggests that selling science and technology through journalistic coverage has become an objective not only for some researchers, but also for some journalists.

I have indicated some of the causes for such trends. They are partly the result of what editorial staffs consider as necessary communication strategies in order to make complex issues engaging. The images and layouts visually argue for the value of the research, in this way also reflecting how science stories in newspapers compete for reader attention with stories that have more obvious news value, such as crime stories. Furthermore, working within their media frames (time frames, for instance), the people who are responsible for the illustrations and the layout have to draw on a reservoir of formulaic expressions, or so-called *schemata*. A schema may be understood as a kind of model for the representation of different areas of reality (Kjørup 1995). The laboratory man in the white coat with a test tube is

such a model of the scientist and science, a handy image to use in order to create recognition. This image is also invested with a cultural authority, something that, from the reader's viewpoint, may strengthen the status of journalism as a truthful account of reality.

Are there not other ways of representing science and science-related issues visually in journalism? Certainly there are other ways, but I find it difficult to spot clear trends among them, for example as to what characterizes images accompanying articles representative of more critical science coverage. This may be partly due to such journalism seeing scientific research in a broader societal context and not necessarily focusing on research and developments within science as such. The use of images, then, does not necessarily become distinct or different compared to what one finds in critical journalism in other areas.

Let me end this article by relating the subject to my own practical experience as an editor and journalist of the magazine *Apolon*. This is a popular science magazine published by the University of Oslo. An editor of such a publication has a certain obligation to promote the institution's research. That undoubtedly influenced the way I used illustrations. But although I can now clearly see how several articles reproduced the visual clichés in popular science, my ambition as an editor was to develop a kind of journalism that was as critical as possible within the frames mentioned. Part of my goal was to reduce the distance between science and society; a distance that I find that the media have a tendency to maintain. To achieve this purpose, I found the portrait genre most usable, not only because of the freedom the genre provides for the writer, but also for the photographer. Here, the photographer could portray scientists as persons that the reader was invited to engage in a dialogue with, so to speak. An example is the portrait of Niels Christie, Professor of Criminology (Fig. 22).

I have argued that there are certain codes and established conventions guiding the use of images in popular science and science journalism. These codes may be accentuated in different ways, depending on such things as the newspaper's or the magazine's perception of its readers. However, I think there are

a lot of unexplored possibilities for a different visualization in science journalism. One challenge is to portray science and science-related issues in a way that makes us see with “fresh eyes”, so to speak, and invites the viewer to participate in questions connected to scientific research. But contributing to this by the use of images is certainly not a small challenge.

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THE FIGURES REFERRED TO

- Figs. 1, 2: from *Scientific American*, November 1982, copied from Myers (1990)
- Fig. 3: from *Hormones and Behavior*, Vol. 18, 1984, copied from Myers (1990)
- Fig. 4: from *Scientific American*, August 2002
- Figs. 5, 6, 7: from *Scientific American*, April 2002
- Fig. 8: from *Scientific American*, November 2002
- Fig. 9: from *Scientific American*, June 2002
- Fig. 10: from *Scientific American*, September 2003/ *Illustrert Vitenskap* 12/2003
- Fig. 11: from *Illustrert Vitenskap* 3/2000
- Fig. 12: from *Illustrert Vitenskap* 12/2003
- Fig. 13: from *Nationen*, August 2003
- Fig. 14: from *Aftenposten*, 27.08.2003
- Fig. 15: from *VG Nett*, 19.06.2001
- Fig. 16: from *VG Nett*, 05.12.2000
- Fig. 17: from *Scientific American*, December 2002
- Fig. 18: from *Aftenposten*, 03.05.2001
- Fig. 19: from *Aftenposten*, 02.02.2000
- Fig. 20: from *Apollon* 3/1996
- Fig. 21: from *VG Nett*, 27.06.2000
- Fig. 22: from *Apollon* 3/1997

Norwegian Abstract

„Visualisert vitenskap“. Billedillustrasjon i populærvitenskap og forskningsjournalistikk.

HARALD HORNMOEN

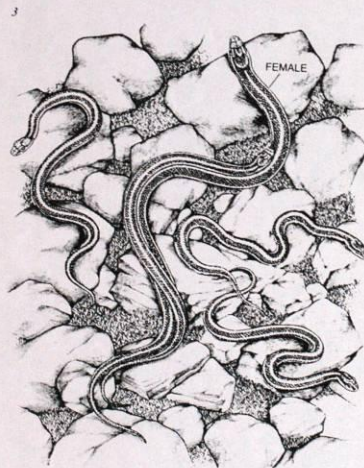
Artikkelen utforsker hvordan forskning og forskere blir representert visuelt i populærvitenskap og forskningsjournalistikk. Den diskuterer hvilke kommunikative funksjoner og kulturelle betydninger visuelle elementer har i artikler om forskning. Ved å anvende begreper fra den visuelle grammatikken utviklet av Gunther Kress og Theo van Leeuwen, antyder forfatteren hvordan ulike typer modalitet blir brukt til å adressere leserne i populærvitenskapelige artikler i magasinene *Scientific American* og *Illustrert Vitenskap*. Forfatteren argumenterer for at de visuelle elementene konvensjonelt blir tilrettelagt med et pedagogisk siktemål, slik at de kan føre leserne fra en virkelighet som de antas å være fortrolig med og henimot mer abstrakt vitenskapelig kunnskap. Det er imidlertid markante forskjeller i måten *Scientific American* og *Illustrert Vitenskap* gjør dette på. Abstraksjonsnivået i *Scientific American* bidrar til å skape en identitet for magasinet lesere som en velutdannet og avansert sosial elite. *Illustrert Vitenskap* legger betydelig mer vekt på naturalistiske avbildninger. Forfatteren diskuterer videre hvordan fotografier, visuelle komposisjoner og verbaltekster virker sammen i en multimodal retorikk som er vanlig i forsknings- og helseartikler i norske aviser.



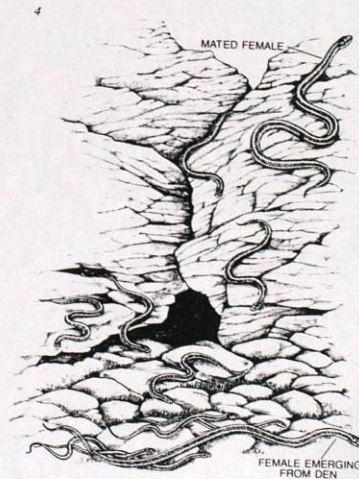
MATING BEHAVIOR of the red-sided garter snake is confined to a short, intense springtime breeding season. For a period of from three days to three weeks the males sun themselves near the den



from which they emerge. Females emerge singly or in small groups (1). Attracted by a pheromone (a messenger substance) on the back of a female, as many as 100 males form a "mating ball" (2). One male

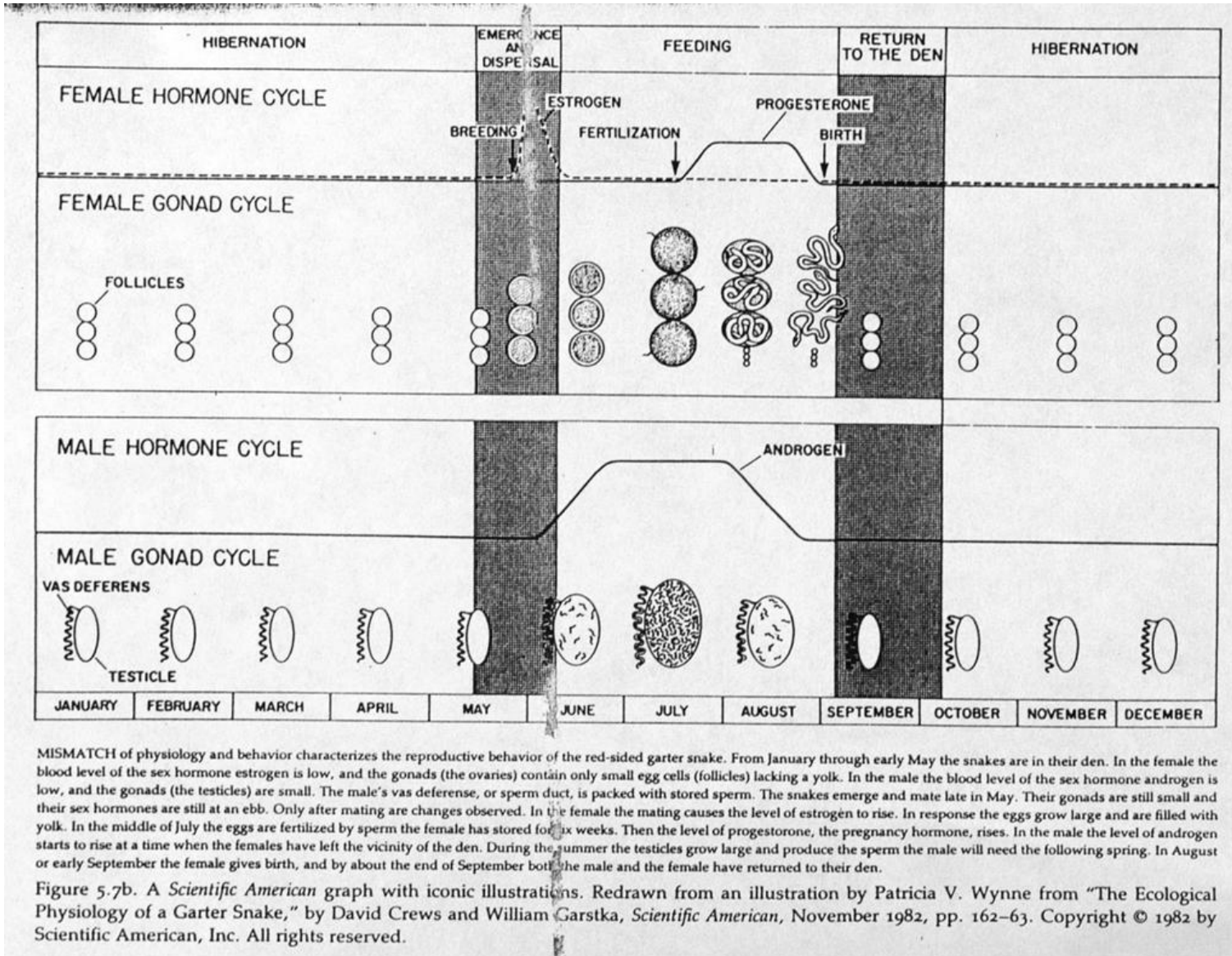


in the ball succeeds in mating with the female by inserting one of his two hemipenes into her cloaca (her urogenital opening). The other males immediately disperse (3). The mated female, rendered unat-



tractive to males by a pheromone her mating partner conveys into her cloaca, immediately leaves the vicinity of the den. The males stay near the den to await the emergence of another unmated female (4).

Figure 5.6. A narrative in illustrations. Illustration by Patricia V. Wynne from "The Ecological Physiology of a Garter Snake," by David Crews and William Garstka, *Scientific American*, November 1982, pp. 160-61. Copyright © 1982 by Scientific American, Inc. All rights reserved.



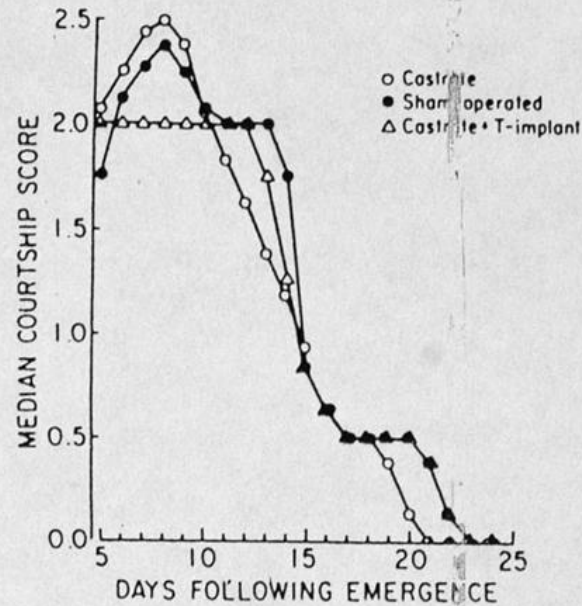


FIG. 1. Changes in courtship behavior of male red-sided garter snakes (*Thamnophis sirtalis parietalis*) on emergence from low-temperature dormancy. In nature following hibernation, or in the laboratory following low-temperature dormancy, courtship behavior initially is vigorous but then gradually declines in intensity; males will not exhibit courtship behavior again unless exposed to cold temperatures. Depicted here is the decline in courtship behavior in males that were castrated, castrated and given testosterone replacement therapy, or sham-operated in the fall prior to entering winter dormancy.

Figure 5.7a. A *Hormones and Behavior* graph. Illustration from "Hormonal Independence of Courtship Behavior in the Male Garter Snake," by David Crews et al., *Hormones and Behavior*, Vol. 18, p. 34. Copyright © 1984 by Academic Press, Inc.

Phytoplankton's Influence on the Global Carbon Cycle

THE EARTH'S CARBON CYCLE can dramatically influence global climate, depending on the relative amounts of heat-trapping carbon dioxide [CO_2] that move into [yellow arrows] and out of [green arrows] the atmosphere and upper ocean, which exchange gases every six years or so. Plantlike organisms called phytoplankton play four critical roles in this cycle. These microscopic ocean dwellers annually incorporate about 50 billion metric tons of carbon into their cells during photosynthesis, which is often stimulated by iron via windblown dust [1]. Phytoplankton also temporarily store CO_2 in the deep ocean via the biological pump: about 15 percent of the carbon they assimilate settles into the deep sea, where it is released as CO_2 as the dead cells decay [2]. Over hundreds of years, upwelling currents transport the dissolved gas and other nutrients back to sunlit surface waters.

A tiny fraction of the dead cells avoids being recycled by becoming part of petroleum deposits or sedimentary rocks in the seafloor. Some of the rock-bound carbon escapes as CO_2 gas and reenters the atmosphere during volcanic eruptions after millions of years of subduction and metamorphism in the planet's interior [3].

Burning of fossil fuels, in contrast, returns CO_2 to the atmosphere about a million times faster [4]. Marine phytoplankton and terrestrial forests cannot naturally incorporate CO_2 quickly enough to mitigate this increase; as a consequence, the global carbon cycle has fallen out of balance, warming the planet. Some people have considered correcting this disparity by fertilizing the oceans with dilute iron solutions to artificially enhance phytoplankton photosynthesis and the biological pump.

—P.G.F.





By directing its victims' sex lives, the bacterial parasite **WOLBACHIA** may be helping to produce new species

GENDER-BASED GENOCIDE
The bacterium *Wolbachia* eliminates male *Acrasis ericadoris* butterflies because only females can serve as hosts for the parasite and pass its spawn on to the next generation.

Parasitic SEX Puppeteers

By Laurence D. Hurst and James P. Randerson

Don't bite the hand that feeds you.

The old adage sums up the approach parasites are expected to take with their victims. A freeloader that can spread only when its host reproduces ought not to be overly harmful: too much damage to its unwilling benefactor will affect the parasite's own chances to procreate. This scheme contrasts with the tactics of a pathogen that has a short infectious period, such as the flu virus. In that case, the virus has no long-term interest in the carrier's well-being, so a "get transmitted quick" strategy is favored almost regardless of the cost to the hapless host.

The widely distributed bacterium *Wolbachia* (a close relative of the

gut bacterium *Escherichia coli*) is a boarder with a long-term interest in its invertebrate host. It lives within cells and is transmitted to the next generation by invading its host's eggs. Contrary to the old saying, however, the bacterium engages in various radical manipulations of its hosts, including killing male offspring, turning males into females and rendering some host matings infertile. If *Wolbachia*'s reproduction is so intimately tied up with that of its meal ticket, why does it create so much havoc?

The short answer is that the bacterium is not carried in sperm. This egg-only propagation method means that the parasite's reproductive interests lie firmly with female hosts. Males, as nontransmitters, are akin to evolutionary prison cells for the bacterium.

Over the course of time, however, Darwinian natural selection has been able to sidestep the parasite's custodial sentence in male hosts. Rather than being a dead end, the problem of nontransmission has been turned into an opportunity. *Wolbachia* may have played much more than a walk-on part in this evolutionary drama because its manipulations can have profound long-term effects on its victims. By interfering with host reproduction, *Wolbachia* may be setting the stage for new species to form.

Wolbachia is highly abundant and has rather catholic tastes in choosing its insect and invertebrate carrier species. When John H. Werren and his colleagues at the University of Rochester screened neotropical insects for the presence of *Wolbachia*, they found that 17 percent of 154 species harbored the bacteria.

The true frequency of infection may well be considerably higher, however. Greg Hurst and his co-workers at University College London and the University of Cambridge have found several well-studied species of *Wolbachia* in about a tenth of the individuals in a host population. Sampling only a few individuals from a given species, as the Rochester group did, is therefore likely to miss many incidences of infection. Further, Marjorie Hoy and Jay Jayaprakash of the University of Florida have determined that the technique employed in the Rochester study often wrongly indicates an absence of parasitization. Using a more robust method, the Florida researchers discovered that more than three quarters of the species they tested were infected with the bacterium.

Nor is the parasite found only in insects; it appears in crustaceans (notably pill bugs and freshwater shrimps), mites and nematode worms as well. So far it has not been detected in a vertebrate animal. We estimate that more than 20 million species may harbor *Wolbachia*, suggesting that scientists have so far studied merely the tip of a huge and important iceberg.

Choosy Males

ONE WAY IN WHICH *Wolbachia* can profoundly influence its victims is by grossly distorting the normally balanced sex ratios of its hosts' populations. For instance, males are extremely rare in some groups of the African butterfly *Acraea encedon* and of the widespread pill bug *Armadillidium vulgare* (also called a wood louse).



COMPULSORY SEX CHANGES and perhaps forced speciation can be traced to the *Wolbachia* bacterium. The tiny parasite transforms would-be male pill bugs (above) into females because it can reproduce only through the female's eggs. The split between two *Nasonia* wasp species (an example is shown at right) seems to have been caused by *Wolbachia*.

In the butterfly, this phenomenon is caused by the pervasiveness of a male-killing strain of *Wolbachia* (more than 90 percent of *A. encedon* females support the parasite). The bacterium presumably kills off males to benefit its own relatives, which are infecting the slain males' sisters. This act of suicide by the individual makes sense because a *Wolbachia* bacterium in a male host is already a "dead man walking." Sperm do not carry the bacterium, so it has no chance of moving to another host anyway; hence, the parasite has nothing to lose. Moreover, its kin in the dead males' sisters benefit from this behavior because male killing occurs before the hosts have hatched. Consequently, a banquet of unhatched male offspring lies there ready to be devoured when the rest of the brood emerges. Such sibling cannibalism by parasitized females is thought to give them an important advantage over competitors.

Although this adaptive advantage has yet to be definitively demonstrated in *A. encedon* caterpillars, it has been established in *Adalia bipunctata*, commonly called the two-spot ladybug (or ladybird). The period between hatching and finding their first aphid meal is a particularly vulnerable time for the larvae of this ladybug. A free lunch provided by a deceased brother is therefore a great boon to them and consequently to the *Wolbachia* they carry.

In pill bugs, *Wolbachia* converts would-be males into females. By feminizing males, the parasite is changing a non-

transmitting host into one that will pass the infection on to its offspring. To return to the prison analogy, this is rather like a convict receiving a hacksaw inside a cake.

In both the butterfly and the pill bug, the bacterium skews the populations' sex ratios massively toward females. Males therefore represent a valuable commodity. This scarcity reverses normal gender roles, because females are in demand in populations with an equal sex ratio. Females make a much larger contribution to the young in the form of large, nutritious eggs, whereas the males' investment of cheap sperm is much smaller. As the chief donors to their young, females are typically much fussier in their choice of mates, accepting only the fittest males.

The selection process is inverted in *Acraea* and *Armadillidium*, however, because males are so hard to come by. Indeed, work by Francis M. Jiggins and his colleagues at the University of Cambridge has revealed that in heavily affected populations of the *A. encedon* butterfly, the entire system of choosing mates has changed. Rather than spreading throughout the habitat, females form dense aggregations on small grassy plots. In one such cluster, 350 butterflies were found packed into a 200-square-meter area. In species with conventional sex roles, such as the sage grouse, these gatherings, known as leks, are where males congregate and females come to shop.

Could the aggregations in *Acraea* represent role-reversed leks to which males come to select a partner? The current evidence is inconclusive. By demonstrating that virgin females are more likely to inhabit the sites than mated females, Jiggins has shown that females are indeed gathering to find mates. The question remains, however, whether the males are doing the choosing.

Jiggins had originally found that mated females are more likely to lack the infection than virgins, implying that males may be selecting uninfected females as partners. Unfortunately, he and one of us (Randerson) have been unable to replicate this result, so the situation continues to be unclear.

In the example of the pill bug, Thierry Rigaud and his collaborators at the University of Poitiers in France have shown that males prefer not to mate with feminized males. Furthermore, if males do mate with transsexual individuals, they deliver relatively few sperm to them.

Our own work using mathematical techniques to model the evolution of choice in these situations has shown that natural selection for such an alteration in mate choice does occur if a host population contains sex-ratio distorters. This result raises the problem, though, of what happens to the parasite when infected females fail to find a mate. The theoretical models show

that when males are able to distinguish perfectly between infected and uninfected females, the bacterium will simply be selected out of the population. If, however, the males occasionally make a mistake and mate with parasitized females, then this is enough to keep *Wolbachia* in the population.

Sex Changes in Hosts

MALE MATE CHOICE may well be one response to the spread of a feminizing bacterium. An even more fascinating one may be the evolution of new mechanisms for genetically determining gender. Research by Rigaud and his associates has shown that *Wolbachia* can determine gender in *A. vulgare*, because male pill bugs have all the genes necessary to become females. All that is needed for an individual to become male is a shot of male-inducing hormone from the "male gland" early in development. Thus, if the parasitic bacterium can block development of this gland, its host will be female.

In some infected populations, the responsibility for gender determination has shifted from the pill bug to its parasite. Pill bugs have what is known as a WZ sex-determination system: males have ZZ chromosomes, and females have WZ. (This arrangement contrasts with the more familiar XY system, in which males are XY and females are XX.) Because only the few eggs that do not contain *Wolbachia* become males, infected WZ females give birth mostly to daughters: both WZ females and sex-changed males (ZZ females). These ZZ females in turn almost exclusively produce ZZ females. As a result, infected females of either type beget more daughters than normal females do. Thus, with each succeeding generation, the proportion of individuals with the normal female chromosome W drops and eventually nears zero. At that point, the parasite is left entirely in control of sex because everyone is ZZ—if the pill bug has the parasite, it's female; if not, it's male. In other infected pill bug groups, the hosts seem to have wrestled back control over their sex ratios by setting the proportion of offspring that receive the bacterium in some as yet undetermined manner.

Wolbachia's most common manipulation is to interfere in the success of the host's matings. Known as cytoplasmic incompatibility, this strategy renders all matings between infected males and uninfected females infertile because the bacterium releases toxins into the sperm's protoplasm [see box on next page]. Other pairings are left unaffected. Halting the procreation of uninfected females indirectly benefits females carrying the bacterium. As a result, these females contribute a large

THE AUTHORS

LAURENCE D. HURST and JAMES P. RANDERSON have studied *Wolbachia* parasites at the University of Bath in England. Hurst is professor of evolutionary genetics at Bath. A recent father, he is interested in the evolution of genetic systems and enjoys the late-period works of Beethoven, walking his dog and attempting to cook. In 2001 Randerson completed his doctoral studies at Bath on the wider evolutionary consequences of selfish organelles and symbionts. He next moved to London to join *New Scientist* magazine as a writer. In his spare time, Randerson plays trombone in a soul/funk band.

THEIRY RIGAUD AT THE UNIVERSITY OF POITIERS

JOHN H. WERREN

er proportion to the next generation, which allows their free-loading *Wolbachia* to spread more widely.

One consequence of this intervention is that the bacterium restricts gene flow between different groups of its host. This is most pronounced in bidirectional cytoplasmic incompatibility, in which two groups of hosts contain mutually incompatible strains of the bacterium. In that instance, all matings between hosts from the different groups are doomed by internal sabotage.

Barriers to free gene flow between populations are all-important in speciation, the origination of new species. In the classic example, biologists imagine that a physical barrier arises, perhaps the formation of a new mountain range or the creation of an island resulting from a rise in sea level. This obstacle splits a previously homogeneous population into two, preventing interbreeding between the new populations and allowing them

to drift apart genetically. Over time the groups diverge to the point that they can no longer interbreed if they are later brought together. Because their parents' genetic systems are now incompatible, hybrid offspring either do not survive or are sterile.

On the Road to Speciation

BIOLOGISTS FAMILIAR with *Wolbachia* began to ask whether the impediments to gene flow created by cytoplasmic incompatibility could be enough to allow a population to bifurcate genetically without the existence of a physical obstruction. Were these bacterial freeloaders the agents of what might be called infectious speciation?

This question is difficult to answer because the process by which one species splits into two takes a long time to complete, much longer than the lifetimes of evolutionary biologists. The

Sexual Sabotage

AN IMPORTANT ADAPTIVE tactic employed by some strains of the *Wolbachia* bacterial parasite is to interfere in the success of host matings by rendering certain pairings barren. By restricting the gene flow among its hosts, *Wolbachia* is thought to be contributing to the development of new species.

Cytoplasmic incompatibility, as the phenomenon is called, occurs when an infected male and an uninfected female attempt to mate. As an evolutionary strategy, it involves indirectly helping hosts that contain one's relatives by harming those that don't.

In males, some strains of *Wolbachia* add a toxin to the host's sperm, which probably alters the proteins that bind to DNA. The poisonous agent causes the male's chromosomes to condense abnormally on fusion with the egg and stops the newly formed zygote from developing. When the male mates with an infected female, however, no such condensation occurs. In this case, *Wolbachia* deploys an antitoxin in the egg that rescues the zygote.

This manipulation of the host by the bacterium has been interpreted as an act of evolutionary spite because it reduces the fertility of unparasitized females with no direct benefit to those bacteria that sabotage the sperm. The strategy is successful, however, because it indirectly benefits infected females and hence their resident *Wolbachia*. These females have

no restrictions on their choice of mates and thus have an advantage over parasite-free females. As infected females beget more infected females, this strategy promotes the spread of the bacterium. Michael Turelli of the University of California at Davis and Ary A. Hoffmann of La Trobe University in Australia have uncovered good evidence

one direction are sabotaged. Things get more interesting if there is more than one strain that produces cytoplasmic incompatibility, a situation known as bidirectional cytoplasmic incompatibility. For the sake of argument, imagine two bacterial strains, A and B. If the egg-sparing antitoxin from strain A is ineffective against the toxin from strain B, and vice



for the success of this approach. In the eastern U.S., the so-called *Riverside* strain of *Wolbachia* that causes cytoplasmic incompatibility is spreading through the territory of its host population [the fruit fly *Drosophila simulans*] along a front fly traveling about 100 kilometers a year.

In unidirectional cytoplasmic incompatibility, just one strain of *Wolbachia* is involved, so matings in only

versa, then matings in either direction are incompatible. If all individuals in the population are infected with one strain or the other, the only successful matings are those between individuals harboring the same strain. Host matings between strains will always lead to incompatibility. The two *Wolbachia* strains have split the host population into two groups that cannot interbreed. —L.D.H. and J.P.R.

UNWANTED HITCHHIKERS. *Wolbachia* bacteria reproduce only through their female hosts, making males superfluous. The parasites are shown here as lighter green spots on an insect egg (top) and as specks inside an infected cell (bottom).



best that can be done is to look for *Wolbachia* hosts that exhibit cytoplasmic incompatibility and are on the pathway to speciation. By studying such suggestive examples, biologists hope to determine whether the parasite is likely to be a force in the evolution of new species.

Two species of parasitic wasp that appear to be near the end of such a journey are *Nasonia vitripennis* and *N. giraulti*, both of which are found in eastern North America. An investigation of these wasps by Johannes A. J. Breucwer of the University of Amsterdam and Werren of the University of Rochester revealed that the barriers to successful mating between these species are not determined solely by differences between the wasps themselves—*Wolbachia* is involved. The researchers found that when both species are treated with antibiotics, inviable offspring result because each wasp species contains a different strain of the parasite, leading to bidirectional cytoplasmic incompatibility between the hosts.

Wolbachia is not the only cause of current isolation between these two species of *Nasonia*, though. The second generation of hybrid wasps tends to have severe developmental problems, perhaps indicating that genetic changes in the wasps' own DNA are now sufficient to keep the two species apart. Whether the parasite was involved in promoting this divergence in the past has not been determined.

In the case of the reproductive separation between *N. giraulti* and *N. longicornis*, the story is different. These two parasitic wasps have been taxonomically determined to be different species—for example, they parasitize different host groups. But again, *Wolbachia* plays a key role—in this instance, by causing bidirectional cytoplasmic incompatibility. Werren and his University of Rochester colleagues Seth Bordenstein and Patrick O'Hara have recently shown that in the absence of the bacterium, the hybrids are normal and remain so in subsequent generations. Although genetic divergence of the wasps' DNA has yet to occur, *Wolbachia* appears to be on the cusp of forcing the evolution of new species.

In some cases, *Wolbachia* may contribute to the process of speciation without being the primary cause. A team of researchers, including D. DeWayne Shoemaker of Western Michigan University, Vanhali Katju of Indiana University and John Jaenike of the University of Rochester, has turned up ev-

idence that even the incomplete obstacle to gene flow provided by unidirectional cytoplasmic incompatibility can contribute to reproductive isolation [see box on opposite page].

Shoemaker and his co-workers looked at two species of fruit fly, *Drosophila recens* and *D. subquinaria*. The first of these is infected with a *Wolbachia* strain that causes cytoplasmic incompatibility; the second is uninfected. As a result, matings between *D. subquinaria* females and *D. recens* males are infertile. If *Wolbachia* were the only factor at work, then gene flow between the fruit-fly species would still be possible, but it turns out that these matings do not occur successfully. Unlike *D. subquinaria*, *D. recens* females are quite choosy when selecting mates, hardly ever picking a male of the other species by mistake. Hence, the two barrier mechanisms complement each other. Gene flow in one direction is prevented by *Wolbachia* (even though matings occur), whereas the flow in the reverse direction is prevented by careful mate choice by *D. recens* females.

Despite these and other suggestive examples, the case for infectious speciation has yet to be proved. It is notable, however, that *Wolbachia* infections are especially prevalent in insects and mites, the most species-rich animal groups. Perhaps *Wolbachia* had a hand in nurturing new shoots on these bushy branches of the tree of life.

Who's Running the Show?

FAR FROM BEING a minor freeloader, the *Wolbachia* parasite is widespread in nature and manipulates the reproduction of a variety of host organisms in diverse ways. What is more, attempts by the bacterium's hosts to evade infection have sent their biology and evolution in unexpected directions. As scientists begin to explore more of *Wolbachia*'s still hidden biology, we expect this influential passenger to have other surprises in store.

MORE TO EXPLORE

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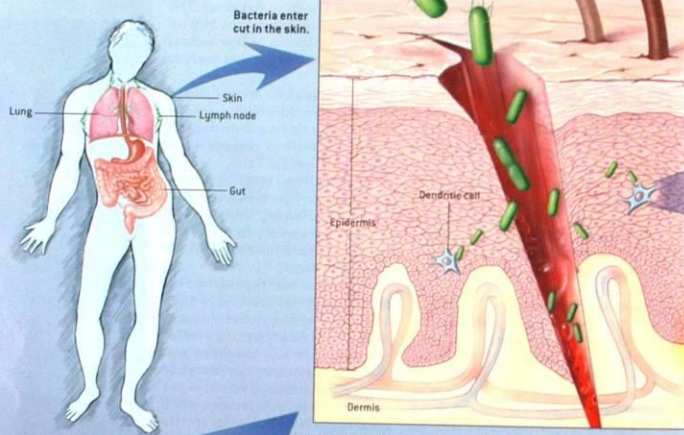
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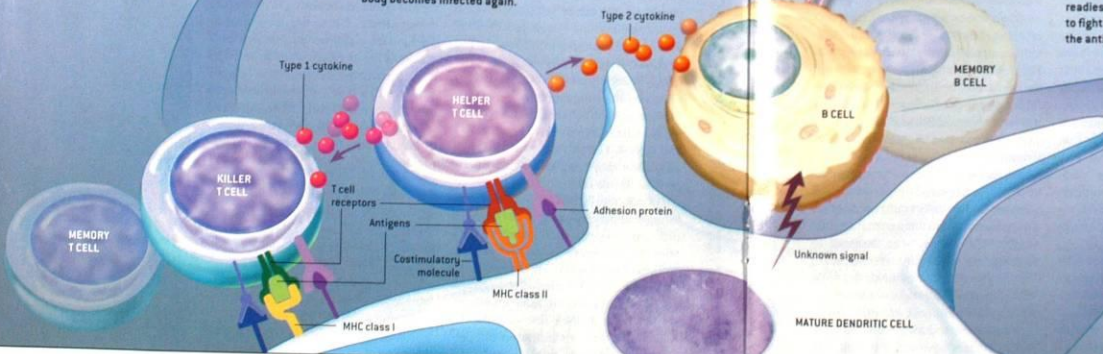
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DENDRITIC CELLS AND INFECTION

PRESENT IN THE LUNGS, skin, gut and lymph nodes, dendritic cells orchestrate the immune response against invaders (here, bacteria entering a cut in the skin).



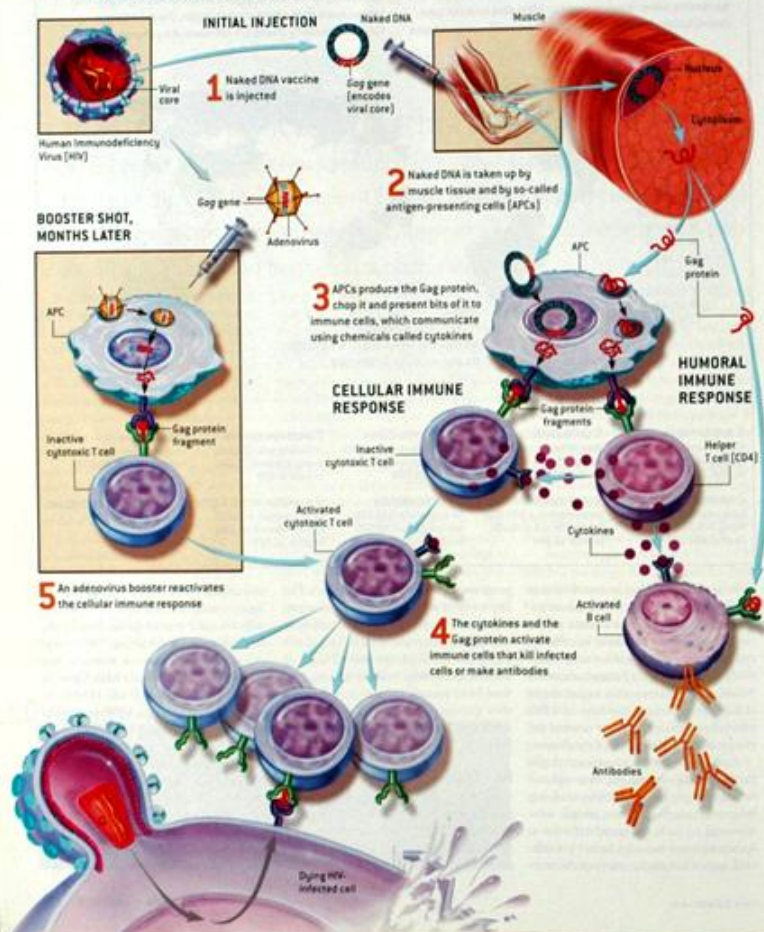
Dendritic cells bind to helper T cells, killer T cells and—perhaps—B cells. The binding prompts the helper T cells to make substances called cytokines that stimulate killer T cells and cause B cells to begin making antibodies. The antibodies and killer T cells migrate to the cut to fight the infection. Memory cells persist in case the body becomes infected again.



One AIDS Vaccine Strategy

A VACCINE APPROACH being pioneered by Merck involves an initial injection of a naked DNA vaccine followed months later by a booster shot of crippled, genetically altered adenovirus particles. Both are designed to elicit an immune response targeted to the HIV core protein, Gag, and

to primarily arouse the cellular arm of the immune system—the one that uses cytotoxic T cells to destroy virus-infected cells. The naked DNA vaccine also results in the production of antibody molecules against Gag, but such antibodies are not very useful in fighting HIV



monogenicity, its ability to prompt an immune response. In phase III, the potential vaccine is given to thousands of volunteers who are followed for a long time to see whether it protects them from infection. Phase III trials for any drug tend to be costly and difficult to administer. And the AIDS trials are especially challenging because of an ironic requirement: subjects who receive the vaccine must be counseled extensively on how to reduce their chances of infection. They are told, for instance, to use condoms or, in the case of intravenous drug users, clean needles because HIV is spread through sex or blood-to-blood contact.

lating the cellular arm of the immune system, the part that includes activity by cytotoxic T cells. A growing contingent of investigators suspect that an antibody response alone is not sufficient; a strong cellular response must also be elicited to prevent AIDS.

Indeed, the early findings do not seem encouraging. Last October an independent data-monitoring panel did a preliminary analysis of the results of the North American/European data. Although the panel conducted the analysis primarily to ascertain that the vaccine was causing no dangerous side effects in the volunteers, the reviewers were empowered to recom-

trial, involving nearly 16,000 people. It combines the VaxGen vaccine with a canarypox virus into which scientists have stitched genes that encode gp120 as well as two other proteins—one that makes up the HIV core and one that allows it to reproduce. Because this genetically engineered canarypox virus (made by Aventis Pasteur, headquartered in Lyons, France) enters cells and causes them to display fragments of HIV on their surface, it stimulates the cellular arm of the immune system.

Political wrangling and questions over its scientific value have slowed widespread testing of the gp120/canarypox

Results from the **first large-scale trial** of an AIDS vaccine should become available at the end of **this year**.

Yet the study will yield results only if some people don't heed the counseling and become exposed anyway.

The first potential vaccine to have reached phase III consists of gp120, a protein that studs the outer envelope of HIV and that the virus uses to latch onto and infect cells. In theory, at least, the presence of gp120 in the bloodstream should activate the recipient's immune system, causing it to quickly mount an attack targeted to gp120 if HIV later finds its way into the body.

This vaccine, which is produced by VaxGen in Brisbane, Calif.—a spin-off of biotech juggernaut Genentech in South San Francisco—is being tested in more than 5,400 people (mostly homosexual men) in North America and Europe and in roughly 2,500 intravenous drug users in Southeast Asia. The results from the North American/European trial, which began in 1998, are expected to be announced near the end of this year.

Many AIDS researchers are skeptical of VaxGen's approach because gp120 normally occurs in clumps of three on the surface of the virus, and the company's vaccine employs the molecule in its monomeric, or single-molecule, form. Moreover, vaccines made of just protein generally elicit only an antibody, or humoral, response, without greatly stimu-

lating the cellular arm of the immune system, the part that includes activity by cytotoxic T cells.

For its part, VaxGen asserts that it will seek U.S. Food and Drug Administration approval to sell the vaccine even if the phase III trials show that it reduces a person's likelihood of infection by as little as 30 percent. Company president and co-founder Donald P. Francis points out that the first polio vaccine, developed by Jonas Salk in 1954, was only 60 percent effective, yet it slashed the incidence of polio in the U.S. quickly and dramatically.

This approach could backfire, though, if people who receive a partially effective AIDS vaccine believe they are then protected from infection and can engage in risky behaviors. Karen M. Kuntz and Elizabeth Bogard of the Harvard School of Public Health have constructed a computer model simulating the effects of such a vaccine in a group of injection drug users in Thailand. According to their model, a 30 percent effective vaccine would not slow the spread of AIDS in a community if 90 percent of the people who received it went back to sharing needles or using dirty needles. They found that such reversion to risky behavior would not wash out the public health benefit if a vaccine were at least 75 percent effective.

The controversial study set to begin in Thailand is also a large-scale phase III

vaccine. Initially the National Institute of Allergy and Infectious Diseases (NIAID) and the U.S. Department of Defense were scheduled to conduct essentially duplicate trials of the vaccine. But NIAID pulled the plug on its trial after an examination of the data from a phase II study showed that fewer than 30 percent of the volunteers generated cytotoxic T cells against HIV. And in a bureaucratic twist, this past January the White House transferred the budget for the Defense Department trial over to NIAID as part of an effort to streamline AIDS research.

Peggy Johnston, assistant director of AIDS vaccine research, says she expects there will be a trial of the vaccine but emphasizes that "it will be a Thai trial; we won't have any [NIAID] people there on the ground running things."

Critics cite these machinations as a case study of politics getting in the way of progress against AIDS. "There's little science involved" in the trial, claims one skeptic, who wonders why the Thais aren't asking, "If it's not good enough for America, how come it's good enough for us?" Others point out that the trial, which was conceived by the Defense Department, will answer only the question of whether the vaccine works; it won't collect any data that scientists could use to explain its potential failure.

ILLUSTRER VITENSKAP

START
TEMA-
NUMMER

- Genfeil gjorde oss intelligente
- Barna våre får høyere IQ
- Dyrene er klokere enn vi tror
- Klisterhjerne er ren teknikk
- Datamaskinen tar oss igjen om 20 år

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Vi yter mest når vi er stresset
Stress er et tegn på at vi ruster oss til å yte noe utenom det vanlige. Kroppen mobiliserer all sin energi til å klare den aktuelle utfordringen.

1. Kroppen forbereder seg på stor fysisk aktivitet
2. Kroppen yter sitt ytterste, og vi er optimalt aktivtliggende.
3. Kroppen blir nedslitt og syk. Bare søvn og hvile hjelper.

Yteevne

Alarmfase Tilpasningsfase Utmattelsesfase

Grad av stress

- ▶ *Vi trenger stress for å klare hverdagen*
- ▶ *Langvarig stress kan ta livet av oss*
- ▶ *Ett eneste hormon styrer den hårfine balansen*

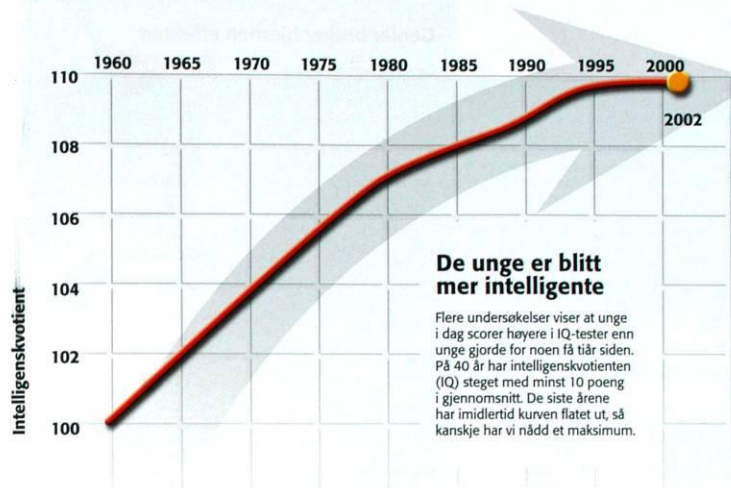
STRESS



Sjakktalentene blir hele tiden yngre, og det kan henge sammen med at intelligensen stiger. Bare 8 år gamle David Howell vant i 1999 et parti sjakk han spilte mot en britisk stormester.

24

Illustrert Vitenskap nr. 12/2003



Vi blir klokere og klokere

Den gjennomsnittlige intelligensen er blitt vesentlig høyere de siste tiårene, antakelig fordi hjernen blir stimulert som aldri før. Men forskerne er ennå uenige om hva intelligens egentlig er.

Psykologene undret seg. Gang på gang måtte de endre testene de brukte for å måle intelligens. Både barn og unge klarte flere oppgaver enn tidligere, slik at de måtte finne på nye og vanskeligere oppgaver for å holde gjennomsnittet nede på 100 når de målte IQ. Først langsomt gikk det opp for forskerne at det ikke var testene det var noe i veien med, men at barn og unge mennesker ganske enkelt var blitt klokere.

Intelligensen er blitt markant høyere, men forskerne er uenige om nøyaktig hvor mye det er snakk om. Et dansk anslag basert på IQ-målinger av unge menn på

sesjon viser en stigning på 10 poeng i løpet av 40 år. Andre målinger kommer til en stigning på hele 20-25 poeng på 50 år. Men ett er sikkert. Det er særlig én del av prøvene i IQ-testen som de nye generasjonene klarer mye bedre. Det gjelder blant annet visuelle og romlige prøver der man for eksempel skal dreie en terning i tankene. Derimot har det ikke skjedd noen stor endring i de delene av testen som omfatter testpersonenes språklige og matematiske-logiske evner.

Stigningen i intelligens er blitt konstatert i en rekke land. Den kalles Flynn-effekten, oppkalt etter professor James ▶

Illustrert Vitenskap nr. 12/2003

Av Ib Salomon. Oppgavetekster og tegninger: Anker Tiedemann 25



FORBRUK: Matindustrien lokker oss til høyere forbruk med flere søte produkter. Brus står for mye av veksten i sukkerkonsumet i Norge.

FOTO: SCANPIX

Svært usunn mat fra industrien

Mat ● Større brusflasker, mer sukker og større matporsjoner. Det er noen av triksene matindustrien bruker for å få oss til å spise mer. Nå har WHO satt i gang arbeidet med å få ned forbruket av usunn mat.

Jon Olav Folsland
jon.folsland@nationen.no

I går skrev *Nationen* om forsker Runar Døving som mener at ferietiden fører til så mye fråtsing at det nærmest er blitt tvangstanker for nordmenn. Den internasjonale matindustrien gjør også hva den kan for at vi skal spise så mye og usunt som mulig. Det gjøres blant annet ved å tilsette sukker i maten. Forbrukerrådet testet forleden en «sunn» matvare som frokostblandinger og fant at opptil halvparten av innhol-

det var sukker. Også matvarer som yoghurt, brød og barne-mat blir tilsatt sukker. Professor i ernæring Kaare N. Norum mener sukkerforbruket blant den norske befolkning fører til dårligere helse, spesielt hos barn og unge.

– Det er bekymringsfullt utfra barns overvekt. Det er en epidemi over hele verden, sier Norum.

Skjevt

Verdens helseorganisasjon (WHO) mener at sukker ikke bør være mer enn 10 prosent av den samlede energien vi får i oss. I Norge ligger vi på 13-14 prosent, men det er svært skjevt fordelt. Noen spiser svært mye mer sukker enn andre.

– Barn og ungdom spiser mer sukker enn gjennomsnittet. Det henger for en stor del sammen med økningen i konsumet av sukretede leskedrikker. Men også søte frokostblandinger og søt yoghurt konsumeres det mye av, sier Norum, som ikke er i tvil om årsaken.

– Det er godt med søte ting, det er ingen tvil om det. Barn

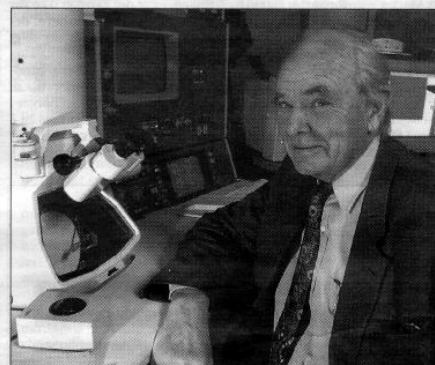
liker sukker, og det er det som er baktanken til næringsmiddelindustrien, sier professoren, som mener sukkerinntaket er svært bekymringsfullt for folkehelsen.

– Umiddelbart fører sukkerinntaket til tannrøte. På lang sikt fører det til overvekt som igjen gir sekundære effekter som tannrøte og diabetes, sier Norum.

Mindre porsjoner

Norum leder en internasjonal referansegruppe som Verdens Helseorganisasjon har satt ned for bekjempe blant annet problemet med sukker. Der står blant annet kampen mot næringsmiddelindustrien.

– WHO går blant annet inn for å få næringsmiddelindustrien til å lage mindre porsjoner, sier Norum. Dette problemet er klart størst i USA, hvor forskning har vist at porsjonsstørrelsene nærmest har eksplodert de siste årene. En normal porsjon pommes frites inneholdt i 1960 200 kalorier, mens 600 kalorier er normalen i dag. Men også i Norge har de-



BEKYMRET: Ernærings ekspert Kaare N. Norum er bekymret for vårt økte sukkerforbruk.

ler av næringsmiddelindustrien økt mengden for å få oss til å spise mer. På 70-tallet inneholdt for eksempel en normal flaske brus 250 milliliter. I dag er normalen en halv liter, en økning på 100 prosent. Norum

ønsker også en mindre aggressiv markedsføring.

– Det er blitt en ubalanse og dette er et sammensatt problem, men vi ønsker i alle fall en strammere regulering av markedsføring og reklame, sier Norum.

Psykiatri. Det er mot et bakteppe av psykiatri sa-

svarene i utvalgte områdene i Kragerø tingrett i november.

Denne saken fordi hun ikke var strafforetslig tilregnelig. Likevel var det en over-

Kvinnens advokat Sverin Morten Torsnes mottok i går et tilbud fra selskapet. - Vi må nå dis-

skaffe nye Aftenpostens erfarer ligger tilbudet mellom en halv og en million kroner.

Sist planeten Mars var så nær Jorden som i dag, satt neandertalere rundt leirbålet. Neste gang vil være om 284 år. Da har menneskene sannsynligvis baser på vår naboplanet.

Mars nærmere enn på 60 000 år

ROLF L. LARSEN

Historisk. Kom deg derfor ut for å se den røde planeten i dag. Den er historisk nær.

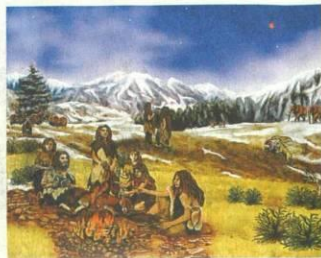
Klokken 11.51 er avstanden til Mars -bare ca. 56 millioner millioner kilometer. Det er ca. 60 000 år siden den røde planeten var så nær Jorden. Neste gang vår naboplanet og Jorden er like nær hverandre, vil være i 2287. Da har menneskene sannsynligvis selv inntatt planeten! Nå må vi nøye oss med å se vår kanskje fremtidige utpost i rommet, fra bakken:

- Mars vil være synlig med det blotte øye som en intens lysende, rød flekk på himmelen. Den kommer opp i sydøst ved 22-tiden, beveger seg mot sydvest og er synlig frem til den forsvinner i morgengylset, sier stipendiat Knut Jørgen Røed Ødegaard ved Astrofysisk institutt ved Universitetet i Oslo.

Bra på Østlandet

De beste observasjonsforholdene her i landet blir i Sør-Norge i kveld. - Det blir bra vær på Østlandet og Sørlandet, sier vakt-havende på Blindern, statsmeteorolog Olav Erikstad. Ellers i landet blir det mye regnbyger og overskyet.

Men folk behøver ikke fortvile, selv om været blir dårlig flere steder i dag: - Mars vil være flott synlig, både med det blotte øye og i stjernekikkert ut august og også i begynnelsen av september. Med en normal stjernekikkert som gir 70 ganger forstørrelse, vil du kunne se Mars like flott som du ser på fullmånen med det blotte øye, forteller astronom.



60 000 år siden. Sist Jorden var så nær Mars, satt neandertalere rundt leirbålet. ILLUSTRASJON: NASA

I kveld vil Norsk Astronomisk Selskap stille stjernekikkerer til disposisjon på Nedre Blindern i Oslo. Mars-arrangementet vil vare fra kl. 23.30 til 02.00.

Hvorfor skjer dette nå?

Mars er spesielt nær Jorden med 15-17 års mellomrom. Sist gang var i 1988 og før det i 1971 og 1956. Denne gangen kommer Mars enda litt nærmere enn den var de forrige gangene.

- Alle planetene i solsystemet går i svakt avlange baner rundt Solen. De fleste banene er ganske sirkulære, men ikke mer enn at avstanden til Solen varierer med flere millioner kilometer. For eksempel varierer Jordens avstand fra Solen mellom 146 og 152 millioner kilometer. Middellavstanden mellom Mars og Solen er ca. 228 millioner km, men banen til Mars er vesentlig mer avlang enn det jordbanen er, forklarer astronomen.

Ut i fra dette ser vi at Mars og Jorden kommer nærmest hverandre der-

som Mars er nærmest og Jorden lengst fra Solen på samme tid. I tillegg endres banene litt. Tyngdekraftene fra andre objekter i Solsystemet forandrer banenes form hele tiden. Dette gjør f.eks. at Jordens bane kan bli mer sirkulær enn nå, men også den kan bli mer avlang. Banene til Mars og Jorden er for tiden slik at neste nærmøte kommer -allerede- år 2287, sier Røed Ødegaard.

Romsunder på vei

Mars er over halvparten så stor som Jorden, har en meget tynn atmosfære og en stor rustfarget, ørkenaktig overflate. Den røde fargen skyldes oksiderte jernmetaller i overflates-teiene.

Mars er fortsatt omgitt av mye mystikk. Mens vi i dag vet at det ikke er - eller har vært - små grønne menn på den røde planeten, har romsunder oppdaget en rekke spor etter rennende vann. Til tross for at Mars er langt mindre enn Jorden, har den en del likhetstrekk: Den har to polkalotter av is, den

Mars nærmest Jorden siden steinalderen

Mars er i dag nærmere enn den har vært på nesten 60 000 år. Vår naboplanet er under 56 millioner km fra Jorden.

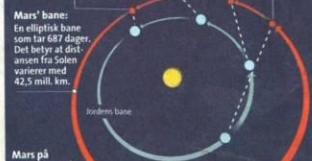
Fakta om Mars:
• Størrelsen er vel halvparten av Jordens, diameteren er 6790 km
• Tyngdekraften er omtrent en tredjedel av den på Jorden
• Mars har en meget tynn atmosfære som for det meste består av karbondioksid - CO₂

• ET Mars-døgn er 24 timer og 37 minutter

• Gjennomsnittstemperaturen er minus 55, men temperaturen varierer fra minus 133 i polare områdene om vinteren til plus 24 grader på solsiden om sommeren.

Nærkontakt: Mars beveger seg rundt Solen rundt halvannen gang lenger borte enn Jorden. Omkring hver 26. måned kommer Jorden på midten av Mars og de to planetene er på linje med Solen.

27. august: 56 millioner km 1. mai: 98 millioner km 1. mars: 179 millioner km 1. januar: 267 millioner km



Kilde: REUTERS-Royal Astronomical Society/Astrofysisk institutt/UD © APTEPOSTEN CRAWFA



Om 284 år. Neste gang har menneskene sannsynligvis baser på den røde planeten. ILLUSTRASJON: NASA

har nesten samme døglengde og den er den mest lovende planeten i Solsystemet når det gjelder muligheten for å finne primi-

tiv liv. En europeisk og to amerikanske romsunder er nå på vei for å utnytte den historiske korte reiseavstanden.

nme best?
e allerede i dag.

Europal
små lever til fantastiske priser - all vi krever er at du
for. Du må først være borte noen minutter, kanskje en

ULLEVÅL
universitetssykehus

Hjelp til røykeslutt?

Klinikk for forebyggende medisin (preventiv kardiologi) ved Ullevål universitetssykehus starter nå et prosjekt der man skal undersøke

Person funnet død etter brann i Fitjar

En person ble mandag ettermiddag funnet omkommet etter en brann i et bolighus i Fitjar på Stord i Hordaland natt til søndag.

En dansk mann er savnet etter brannen.

Siste syv dager

Dagens VG

Tips VG Nett

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Rampelys

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Fremtiden blir kald og svart

VG FØLGER

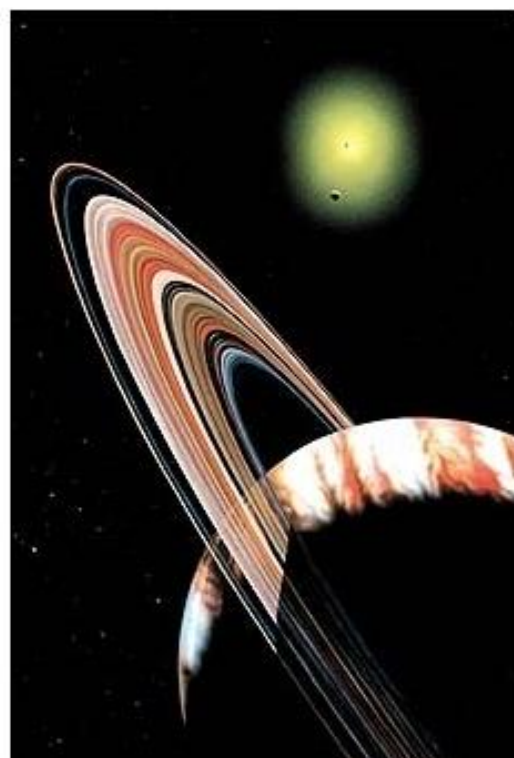
Romfart

Universets skjebne er omsider avslørt. Fremtiden blir kald, svart og uendelig.

 [Tips en venn om denne saken!](#) - [Se dagens mest populære tips!](#)

Av *LINN SANDBERG SKARSTEIN*

Denne sensasjonen kom frem etter et av de lengste og viktigste eksperimenter innen partikkelfysikk utført noensinne. Resultatene ble kunngjort for en måpende skare av vitenskapsmenn verden rundt i går ettermiddag. Mange forskere har lenge hvilt på teorien om en såkalt «Big Crunch» - det vil si en tro på at alt i



Lave priser - Høy kvalitet

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Sikre bevis for vann på Mars

OSLO: For første gang har forskere funnet sikre bevis for at det har eksistert store sjøer med vann på planeten Mars. Funnet setter fart i spekulasjonene om liv på andre planeter enn jorden.

✉ [Tips en venn om denne saken!](#) - [Se dagens mest populære tips!](#)
 📷 [Se også vår bildespesial Vann på Mars.](#)

-Der hvor det er vann er det håp om liv, sier forsker Knut Jørgen Røed Ødegaard ved Astrofysisk Institutt ved Universitetet i Oslo til NTB.

Store mengder vann

Det er høyoppløselige bilder fra det amerikanske romfartøyet Mars Global Surveyor som avslører at Mars har lag på lag med sedimentære bergarter, som vi kjenner dem fra jorden. Dette betyr sannsynligvis at det for flere milliarder år siden eksisterte store mengder vann på planeten.



DEN RØDE PLANET: Dette bildet av Mars eller «Den røde planet» som den også kalles, er tatt av NASA Hubble Space Telescope i mars 1997. Nå har forskerne funnet bevis for at det har vært sjøer på planeten. Foto: AP

Lave priser - Høy kvalitet

PARKETT

**Finn
håndverkeren
her!**

mine
linser

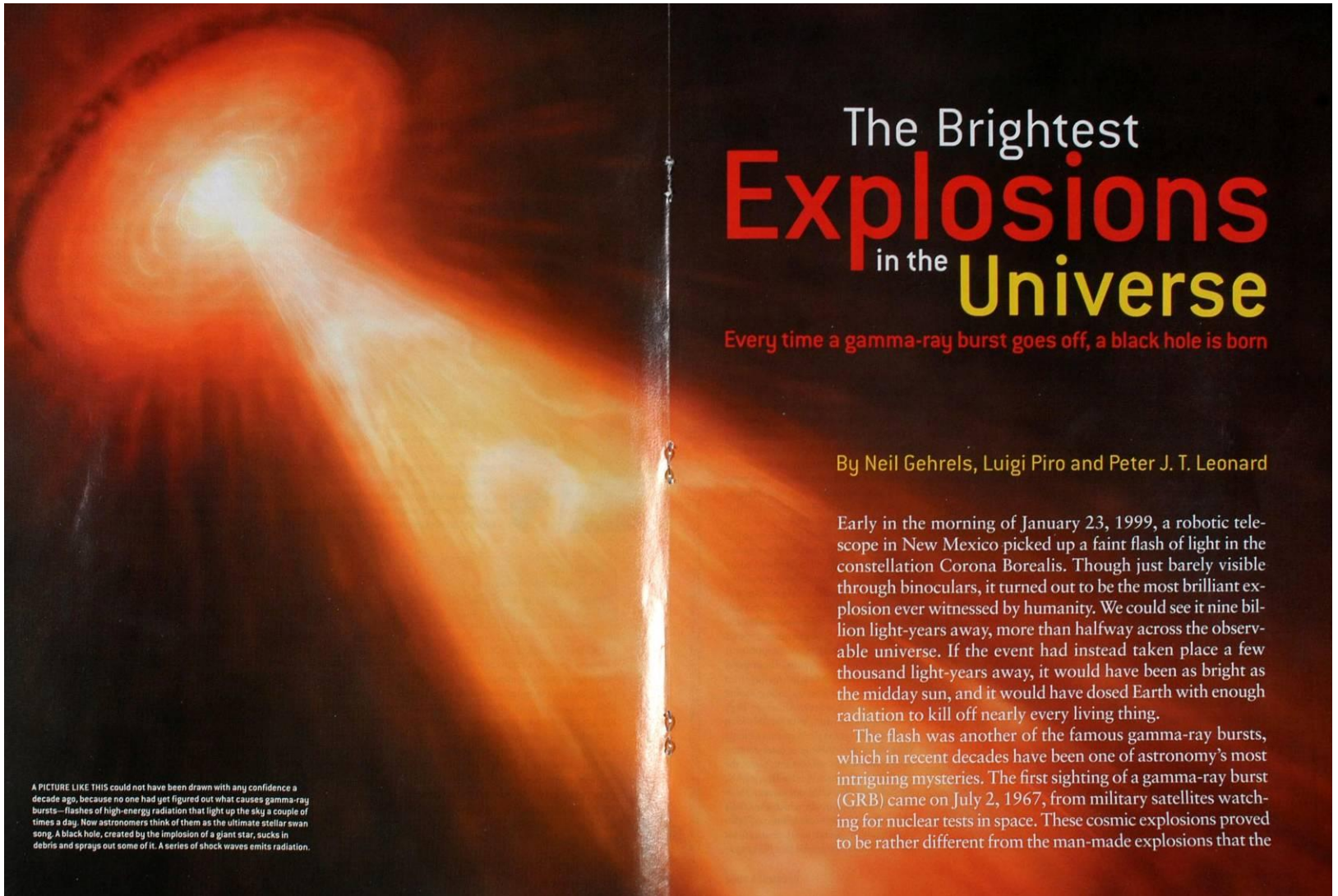


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The Brightest Explosions in the Universe

Every time a gamma-ray burst goes off, a black hole is born

By Neil Gehrels, Luigi Piro and Peter J. T. Leonard

Early in the morning of January 23, 1999, a robotic telescope in New Mexico picked up a faint flash of light in the constellation Corona Borealis. Though just barely visible through binoculars, it turned out to be the most brilliant explosion ever witnessed by humanity. We could see it nine billion light-years away, more than halfway across the observable universe. If the event had instead taken place a few thousand light-years away, it would have been as bright as the midday sun, and it would have dosed Earth with enough radiation to kill off nearly every living thing.

The flash was another of the famous gamma-ray bursts, which in recent decades have been one of astronomy's most intriguing mysteries. The first sighting of a gamma-ray burst (GRB) came on July 2, 1967, from military satellites watching for nuclear tests in space. These cosmic explosions proved to be rather different from the man-made explosions that the

A PICTURE LIKE THIS could not have been drawn with any confidence a decade ago, because no one had yet figured out what causes gamma-ray bursts—flashes of high-energy radiation that light up the sky a couple of times a day. Now astronomers think of them as the ultimate stellar swan song. A black hole, created by the implosion of a giant star, sucks in debris and sprays out some of it. A series of shock waves emits radiation.

Ny norsk vaksine-metode:

Kan hjelpe mot HIV og kreft

Elektriske støt gjør at genmateriale lettere kan komme inn

i cellene, og det åpner for å lage HIV-vaksiner og behandle kreft.

LENE SKOGSTRØM
ROLF ØHMAN (foto)

Er testet. Metoden har i et par år vært prøvd ut på mus, rotter og kaniner, med godt resultat. Nå prøves den videre ut på større dyr. Metoden gir store muligheter for å lage vaksiner basert på genmateriale mot sykdommer som HIV, malaria eller tuberkulose. Men den kan også brukes som teknikk for å behandle sykdommer som allerede har oppstått. For eksempel kreft. Mange sykdommer som skyldes mangel på et hormon eller protein.

«Elektroporering» kalles teknikken, som forsker Jacob Mathiesen og professor Terje Lømo har utviklet ved Institutt for medisinske basalfag ved Universitet i Oslo. De tok patent på metoden for genterapi og DNA-vaksinasjon i USA for.

Elektroporering betyr å anvende elektriske felt for at genmolekyler (DNA) bedre skal bli tatt opp i kroppens celler. Strømmen «gjør noe med celledemembranene, slik at det blir lettere for DNA-molekylene å trenge igjennom. Avhengig av hvilke gener du anvender, lager dine egne celler den vaksinen du trenger.

Tryggere enn virus

På 80-tallet startet de første forsøkene internasjonalt på å føre DNA, eller genmateriale, direkte inn i cellene. Virus brukes ofte som «bærere» av gener. Noen av virusene egne gener byttes ut med de genene man ønsker å overføre. Dette er en effektiv metode, men å bruke virus

Blant annet fordi virusene kan krysse seg med andre virus. De er vanskelige og kostbare å produsere. DNA-molekylene som den norske metoden benytter seg av, er derimot holdbare, tåler mye og er enkle og billige å fremstille.

Gode resultater

Forskerlaget har lyktes med å overføre deler av genmateriale fra tuberkel-basillen inn i muskelceller på mus og rotter. Når DNA fra tuberkel-basillen sprøytes inn i muskler som blir stimulert elektrisk, blir muskelfibrene tatt opp gjennom cellene og begynt å produsere et protein som normalt lages av tuberkel-basillen. Dette proteinet har i sin tur utløst en immunreaksjon hos forsøksdyrene, et tegn på at dyrene er i ferd med å bli immune mot tuberkulose.

Metoden er også prøvd ut på tre geiter ved Veterinærinstituttet i fjor. Også her hadde metoden effekt, men forsøket var for lite til å få svar på om metoden virker like godt på store som på mindre dyr. Resultatene fra Veterinærinstituttet var nødvendig for å gå videre med forsøket på kuer i Storbritannia, der britiske veterinærer deltar i samarbeidet. I England er tuberkulose et stort problem for storfe, som trolig smittes av grevlinger.

Strøm - en ulempe

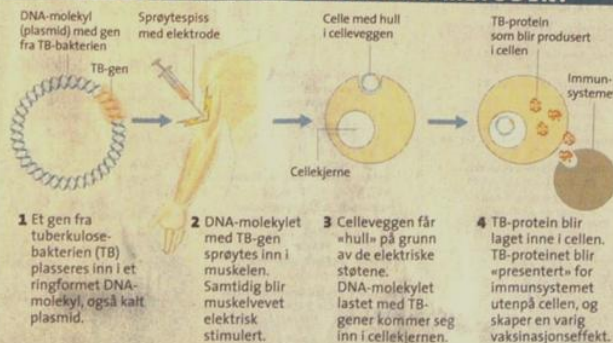
«En ulempe ved vår metode er at den krever elektrisk strøm for å virke. Det er ikke alltid like behagelig. Rotte-ene har fått total-bedøvelse. På geitene gjorde vi det enkelt ved å lokalbedøve et lite område på en muskel, og slik vil vi også gjøre det på kuene. Men strøm-stimuleringen kan gjøre det vanskelig å anvende metoden ved vaksiner av mennesker i stor skala, innrømmer Mathiesen.

Men ved enkelte sykdommer kan metoden likevel brukes på mennesker.



Rotte-vaksine. En spesiell sprøyte med elektroder er laget for å levere strøm og DNA samme sted, forklarer forsker Jacob Mathiesen. Metoden som utvikles kan åpne for å lage blant annet HIV-vaksiner.

SLIK VIRKER DEN NYE VAKSINE-METODEN:



«Klassisk», tradisjonell vaksinasjon går ut på å sprøyte inn svekkede bakterier og virus i kroppen. De gjør at kroppen produserer antistoff – vi blir immune mot sykdommen. Kroppens immunreaksjon blir utløst av spesielle proteiner eller strukturer fra bakterier/virus. Det går an å identifisere nettopp de gen-sekvensene som koder for disse strukturene. Den nye metoden går ut på å sprøyte disse gen-sekvensene inn i kroppens celler. Forsøk med små dyr viser at denne formen for vaksinasjon gir god beskyttelse og åpner for utvikling av mange nye vaksiner.

© Aftenposten Grafikk: Anne Gjertsen

210 000 ikke børsav

210 000 norske arbeidstakere har betalt årsavgiftsdirekte i 16. mai, kan i tillegg målt for sent i tillegg. I år har 3 lerede betalt mars, mot 5 Årsavgift retøy ble he let tjener st arder kronet talt ble det i 2,3 millioner. Det er 50 000 De beste Sogn og Fjordaltinger er i mark.

25 om i trafikk

25 personer i april, n av dem ung deren 16-22 lpspige tall fr Alle de u met som f sjerer i bil. I siste fem år ner omkom ker i april.

I årets fir har 88 pers trafikken. I f rende tallet Blant de månad var 5 passasjerer, 3 fotgjengere som døde v kvinner.

Tønne rygg- i Sveri

Helseminister for at 98 får avslag og Sverige av Bii skal få en ny Sahlgrenska kehus i Göteborg ifølge stat er velrenn tetosykehus e tanse på beh forskning på



Vekker avsky. Kloneet suser, mus med menneskelever på ryggen - det er stort folk synes det er grotesk, mener forskningssjef Geir Gogstad ved Akes Health. Han tror ikke dyrking blir noen stor retning innen bioteknologien. FOTO: SCANTIA

Norsk bioteknologi henger etter

Ett av få. Diatec slår bioteknologi og Internett i én smekk. Det lille selskapet er blant de få i Norge som satsar på en av verdens fremste vekstbransjer - med utradisjonelt distribusjonsapparat.

Naturlige grenser. Bioteknologi fremstår ofte som skremmende: Mus med menneskeører og klonede dyr. Men forskningssjef Geir Gogstad tror naturen setter grenser som teknologien ikke kan passere.

CHRISTIAN HARALDSEN
BOLO CHAMAN (foto)

Hva kan være mer fremtidsrettet enn å kombinere bioteknologi og Internett? Det lille selskapet Diatec er gode nettopp det fra sine kontorer og laboratorier i Forskningsparken i Oslo.

Det kan høres luddig ut, men selskapet har både jordnære ambisjoner i et år om å etablere seg på ca. 2,6 millioner kroner og i år er budsjettet på 4 millioner. Norsk milliardfinansiering vil det for de gamle selskapet aldri bli. I så måte kan selskapet ligne som eksempel på den bioteknologiske bransjen i Norge. Proportjonene er beskjedne.

Norge i bakleksa

Et av Norges største biotech-selskaper, Akas, administrerte med årlige Ståleid i Det Forskningsrådet Geir Gogstad avslår at norske bioteknologiselskaper omsetter for opp mot 1 milliard kroner i dag. Hvis man legger podviven til. Men han ser ingen grunn til at ikke dette tallet skal øke til 50 milliarder kroner i løpet av 20 år. Hvis bransjen får de samme mulighetene til å utvikle seg som andre europeiske land.

Hjelpe en undersøkelse foretatt av det internasjonale revisjons- og konsulentfirmaet Ernst & Young, telt Europa 1028 biotech-selskaper med 29 000 ansatte og et samlet omsættning på 3,1 milliarder dollar i 1997. Samme firma anslår at bransjen synder på 153 000 mennesker og omsatte for 18,6 milliarder dollar i USA i 1998.

Men disse tallene kan lukkede virksomhet vil ikke vanligvis forbindes med bioteknologi. For moderne bioteknologi er knyttet til legemidler og genetikken i en ung bransje, som har ligget i kvartene lenge enn investorene hadde ventet.

Det er først på bioteknologi begynner å bli bruk. Selv om det er USA som leder an, med lang og liberale regler om R&D. Norge henger etter og så sammenheng med våre naboland, til tross for at både kompetanse og risikovillig kapital finnes i riklig mengde. - Vi er forferdede på bakken har Norge, sier Signmund Kværnås i Innovasjon, en offentlig organisasjon som skal bidra til kommersialisering av norsk forskning på bedriftsnivå. - Nye av årsaken kan ha vært at forskere har lært være å ta patent på oppfinnelser. Enten av uventet eller motvillig mot kommersiell anvendelse av forskningsresultater.

Norsk verdiskaping

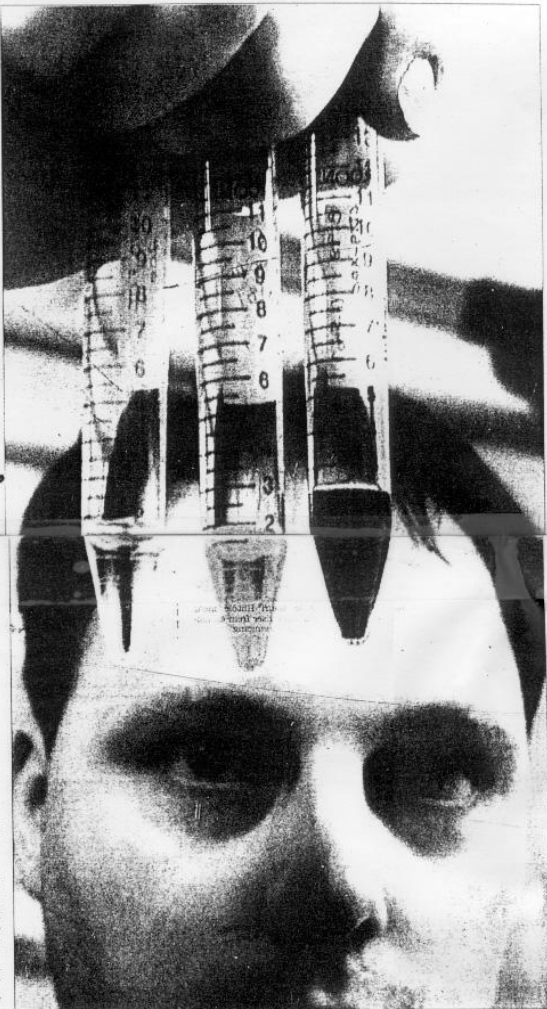
Tillegger Dnyal-sjef Carl Christian Oihus-Moe mener dette har endret seg. Han er nå partner i investeringselskapet Neomed, som disponerer en kvart milliard kroner og spesialisert seg på medisinsk teknologi. Han viser til det arbeidet som blant annet Finn-Ole driver for å sikre at norsk forskning skal lære til norsk verdiskaping. Dette har ført til en holdningsendring blant forskere, mener Oihus-Moe.

Det er en positiv utvikling som har skjedd de siste fire-fem årene, sier han. Oihus-Moe mener oppfinnsomheten er stor blant nordmenn, men at det kan skorte på internasjonalt erfaring. Grundtværne i Diatec er i hovedsak forskere med bakgrunn fra Rikshospitalet, som sammen med daglig leder Bjørn Pedersen er et tre-tredjeler av aksjerne. Resten av aksjene eies av aksjonærene i Sundal Colloid. Foreløpig er det syv ansatte i selskapet.

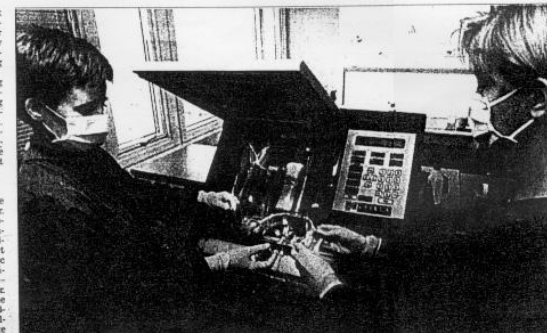
Diatec virkeområdet er i bunn og grunn lite mystisk. Selskapet produserer antistoffer for Rikshospitalet og Usher Sykehus på vei som internasjonale selskaper som Neomed. Markedsledningen skjer nesten utelukkende via Internett og e-post, og dermed kan selskapet operere med lavere priser enn konkurrenter som har et stort selvselskap.

Antistoffer

Diatec er bare en av mange hundre produsenter av antistoffer verden over. Tradisjonelt er antistoffer blitt produsert i dyr, for eksempel mus, som påføres den sykdommen man vil ha antistoffer mot. Dermed produserer dyret antistoffer som så kan utvinnes. Diatec produserer derimot antistoffene i såkalte hullfyllerystemer - Tecnomon - som har flere kommersielle fordeler. Bjørn Pedersen oppgir gjerne at det ville størst med 3000 mus årlig dersom selskapet hadde avhengig den tradisjonelle metoden. Og i den utvænnelige produksjonen har uløst 10 000 krogger i pengene etter fra Portugalen for dyresyk beskjedne.



Fremtiden. Dnyal Røe i Diatec ser mulighetene i bioteknologien, som kan bli dette århundrets største vekstbransje.



Skill teknologier. Hanna Mette Dnyal Kristensen og Høyvil Votr «kluder med Diatec Tecnomon», er kanskje som sporer livet til 3000 laboratorierum drift.

- Liv vil aldri kunne produseres

Fremtiden har ledd for å fortone seg skremmende når bioteknologiske forskere demonstrerer hvor finkle de er. Kloneet suser og mus med menneskeører på ryggen gir ubegripelige assosiasjoner for folk flest.



Geir Gogstad.

- Det er klart at - visper gener dette er slurre ting hver dag - som folk synes er groteske, sier Geir Gogstad om «remuse»-te.

Han er forskningssjef i skotske Akas Health, som har utviklet en rekke analysesystemer basert på bioteknologi. Han tror ikke øredyrking vil bli noen stor retning innen bioteknologien. Markedet for slike ører er rett og slett for lite. Nyredyrking ville det derimot være et betydelig marked for, men Gogstad mener det ligger langt frem i tid.

- Det er ikke sikkert det noen gang blir mulig, sier han, og forklarer at den genetiske konstruksjonen er en type er ubyre komplisert. Etter hans mening tilhør det grenser vitenskapen aldri vil klare å passere.

- Det å starte på et ren kjernak havå og produsere det vi kaller bi, det er noe vi aldri vil få til, Heideguy.

Bioteknologisk vaskepulver
De fleste bioteknologiske produkter er ikke kontroversielle. At utslipp og forpåkning er bioteknologiske prosesser er antagelig ukjent for de fleste. Vaskepulver har inneholdt enzymer - som kan utvinnes fra såkalt «høstet»-kulturer, fisk og gjærmasse - i lenge. Bioteknologisk forskning leder etter hvert til en rekke vakkere legemidler. Hjelpe Gogstad blir de fleste legemidler enten behandlet med Plagrasin, som beskytter benmarg mot «cellegift». Diabetslittere har fått et bedre iv med bioteknologisk insulina.

Genmat er best

Det er i første rekke genetikken som har skrevet skribet og produsert. Allerede til sonen er kan det menneskelige genem være fallende kartlagt. Komplexiteten om genene kan ettervert lede til mer presise legemidler med mindre alvorlige bivirkninger enn dagens. Det kan også bli mulig å forebygge sykdommer heller enn å behandle dem etter at de har brutt ut. Men mulighetene for å forstå hvem som vil få hvilke sykdommer, når er ikke udekket hyggelig.

Da er vi inne på ting som skramler litt etakk, sier Gogstad. Forsikringselskaper kan oppplagt være interessert i å kartlegge hvilke sykdommer hundene er disponert for, selv om de ikke kan forebygges eller behandles. Og slik kunnskap vil nok folk flest foretrekke være foruten.

Også når det gjelder genmodifisering av matvarer ser Gogstad mulige problemer. Men på dette området er vrangforestillingerne mange. Bredtsett - genmat - gir inntrykk av at mat med gener er unormalt og farligere færlig.

- Vi spiser matvarer av gener hver dag, sier Gogstad, og poengterer at det ikke finnes mat uten gener. Men det minste ikke fra naturens side. Men til alt hull blir man ikke grovstakk av å spise genmat.

Gener på avveie

Derimot er ikke vitenskapen samstemt når det gjelder muligheten for at gener skal «komme på avveie» i naturen. Dyrking av genmodifiserte planter har ikke foregått lenge nok til at alle konsekvenser på miljøet er dokumentert. Sleppekjønn frykt for at mangfoldet i naturen skal bli forsvunnet kan ikke avvises, like lite som de selv kan bevise at moderne landbruk blir mer miljøeffektivt med genetiskologisk vitenskap.

Fakta

- **Noen norske bioteknologiselskaper**
- **Afflicch.** Grundtværne som skal bygge et «bibliotek» over antistoffer.
- **Aks Health.** Selskap som utvikler nettest på Oslo Børs. Har blant annet utviklet en test som kan avleke langvarig høyt alkoholforbruk.
- **Biosense.** Bergslagens firma som utvikler bioteknologiske produkter i Finland.
- **Biotech.** Firma i Tromsø som utvikler bioteknologiske produkter i Finland.
- **Diatec.** Produserer antistoffer som selges over Internett.
- **Dnyal.** En av Alpha og Dyno men skal på Børs. Basert på de såkalte Usher-kidene.
- **GeneVitalis.** Grundtværne som har utviklet system for seleksjon av DNA til bruk ved genanalyser.
- **Genpoint.** Grundtværne. Analyse av DNA i 1200 timer.
- **Pharmac.** Har utviklet en behandling mot hudkreft basert på forskning ved Radboud Universitet og har patent på genpatent.
- **Legemiddelekselskapene Alpha og Neomed.** Har også bioteknologisk virksomhet.

Morgendagens manipulerede måltider

– Vi knasker i oss arvestoff hver dag

– Jeg tror at vi om ti år drikker øl brygget på genmodifiserte gjærvarianter og spiser ost laget ved hjelp av genmodifiserte mikroorganismer. Og vi gjør det uten store betenkeligheter. Folk glemmer at de hver eneste dag knasker i seg massevis av arvestoff, sier førsteamanuensis Reidunn Aalen ved Biologisk institutt, Universitetet i Oslo.

Tekst: Ingeborg Wiese

Geneteknologi og landbruk er et stort satsningsområde innen moderne bioteknologi. De som tror på forskningen, spør at den kan bidra til å dekke verdens matvarebehov globalt, mens kritikerne frykter at manipuleringen med naturen kan få store og katastrofale konsekvenser. Og midt imellom står forbrukerne, som til syvende og sist kan velte mange års forskning og kommersiell satsning hvis de ikke vil kjøpe de genmodifiserte produktene.

Genmodifisert tomatplante

I USA har den etter hvert berømte tomaten *Flavr Savr* vært på markedet en stund og skal ifølge det amerikanske selskapet *Caltgene*

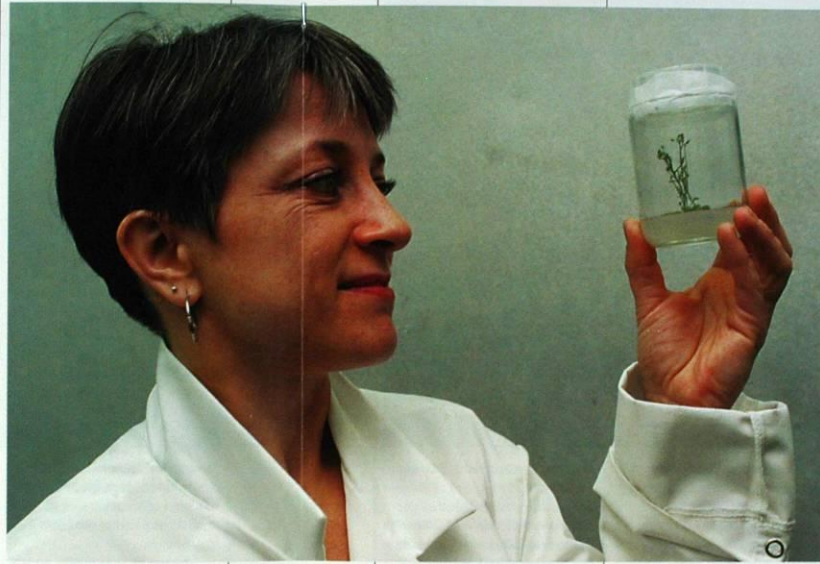
selge bra. Tomatplanten har fått ett av sine egne gener «smudd», slik at en uønsket egenskap bortfaller. Genmodifisering betyr ikke nødvendigvis at en plante får tilført ett eller flere gener fra en annen art, det som forskerne kaller transgene planter. Tomaten har dermed fått lengre holdbarhet ved at celleveggene ikke brytes ned like fort som hos andre tomater. Det betyr igjen at grønnsaken ikke må plukkes når den er grønn for å tåle lagring og frakt, men kan henge på planten til den er moden. Smaken skal være den samme, utseende og næringsinnhold det samme – så hvorfor er vi likevel inngrodd skeptiske?

– Som medlem av Bioteknologinemnda opplever jeg at behovet for informasjon og debatt er enormt, både hos bønder og forbrukere. De fleste vet ikke hva genmodifisert mat egentlig er, men de er intuitivt mistenksomme. Det assosieres lett med kunstig, skadelig eller usunn mat, mener Aalen.

Hovedhensikten med å gi en plante et nytt gen, fra for eksempel en annen planteart, er å forhindre avlingstap forårsaket av sykdom, skadedyr eller ugress. I dag går store deler av verdens avlinger tapt på grunn av ødeleggelser. Planteproduksjonen i utviklingsland er særlig utsatt for insektangrep, og det eneste man har hatt som mottiltak, har vært giftige insektmidler. Intensiv bruk av disse har fått store og negative konsekvenser for folks miljø og helse. Genmodifiserte planter som er resistente mot

for eksempel insekter, kan redusere bruken av giftige midler betydelig, ifølge forskerne.

En annen vesentlig hensikt er å forbedre kvaliteten til planten, ved å gjøre den mer holdbar og øke næringsinnholdet, slik man har gjort med den genmodifiserte tomaten. Bruk av genmodifiserte planter kan også bidra til å utvide dyrkningsmulighetene, ved at plantene blir mer tolerante overfor tørke, kulde eller salt.



Planteforedlere har i århundrer laget nye plantesorter ved å overføre gener ved tradisjonell kryssing og seleksjon. Metoden tar lang tid, men resultatene har gitt planteprodukter med høy kvalitet. Kulturplanter som opprinnelig var uegnet som mat til mennesker og dyr, har gjennom nitid, tradisjonell foredling blitt spiselig og sunn næring.

Moderne geneteknologi kan effektivisere tradisjonell foredling. Genmodifisering av planter åpner

dessuten for helt nye muligheter, blant annet ved at kulturplanter kan tilføres egenskaper ikke bare fra nært beslektede arter, men i prinsippet fra alle grupper av organismer, fra virus til pattedyr.

Forskning på genmodifiserte planter er suksessfull i den forstand at plantene i stor grad oppfører seg som forventet. Til sammenlikning har genterapi på mennesker ikke på langt nær vist samme framgang. Det er enkelt å

Forsker Reidunn Aalen med en genmodifisert plante: – Det er sider ved utviklingen jeg er betenkt over, som at så mange forskere er ansatt i landbruksindustrien og at geneteknologi i så stor grad brukes til å øke profitten nettopp hos den. (Foto: Ståle Skogstad ©)

gi planter nye gener. Fra én genmodifisert plantecelle kan man få en ny plante der alle cellene inneholder det nye genet som gir planten en ny egenskap.

Landbruksindustrien fører an
Både i Europa og USA strømmer det inn søknader til offentlige myndigheter om å få markedsføre genmodifiserte planter. På verdensbasis har allerede 60 plantearter blitt utsatt for genetisk modifisering, og det er utført 3000 felt-eksperiment med transgene planteavlinger.

– Er det i det hele tatt mulig å bremse dette lokomotivet som med all mulig tydelighet er satt i bevegelse?

– Om ti år tror jeg vi spiser genmodifisert mat uten å tenke stort over det. Men det er sider ved utviklingen jeg er betenkt over, som at så mange forskere er ansatt i landbruksindustrien, og at geneteknologi i så stor grad brukes til å øke profitten nettopp hos den. Landbruket er i dag en kjempeindustri, og jeg kunne ønske at teknologien også ble brukt til nyttigere formål. Det er de store næringsmiddelfirmaene som styrer

tema

Kur mot aldring - Microsoft Internet Explorer fra Høgskolen i Oslo

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Kur mot aldring

Av *KARIN MURI*

LONDON (VG) Instruksjonsboken til det menneskelige liv er avdekket. Det kan føre til at forskerne i fremtiden kan utvikle medisiner som utsetter aldring.

Tips en venn om denne saken! - Se dagens mest populære tips!

Det vitenskapelige gjennombruddet karakteriseres som en biologisk månelanding og den hittil viktigste oppdagelsen i menneskets historie.

I går presenterte forskere i Storbritannia og USA et nesten ferdigteget kart

VG FØLGER
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- [Medisinsk revolusjon](#) (27.06.00)



Start Express! 2000 (v1.20 R... Microsoft Word - Dokument3 Kur mot aldring - Micr... Adobe Photoshop

Internet 09:50

– Gi meg et monster!

– Selv om jeg ferdes sammen med mange som regnes som fullstendig umulige, har jeg aldri møtt monstre. Du kan se monstre i folkeeventyrene og i mediene, men gi meg et ordentlig monster, da! Det er merkelig at jeg aldri kan møte et.

Tekst: Marianne Tonnessen

– I de fleste relasjoner synes jeg det er mulig å nå fram til den andre og snakke sammen på en noenlunde rimelig måte, sier Nils Christie.

– Det å skape bilder av den andre som farlig og ond, sperrer for muligheten til å få i gang en samtale.

Vi er i gang med en samtale på hans kontor. Christie har vært ansatt som professor i kriminologi ved Universitetet i Oslo i over 30 år. I løpet av denne tiden har han også rukket å bli kjent for mange kontroversielle utspill i mediene. Men han oppfatter ikke seg selv som kontroversiell:

– Jeg synes jeg er nokså fredelig og grei, og at det som oppfattes som kontroversielt, er nesten selvfølgelig observerasjoner. Hva slags utspill tenker du på?

– Du har jo allerede for lenge siden gått inn for å legalisere hasj, du har sammenliknet metadon med insulin, du er skeptisk til integrering av innvandrere og

hevder at ghettoer har fordeler, du har kritisert psykiatrien kraftig, du mener det er for få voktere på T-banen, og du sier at norsk narkotikapolitikk er fullstendig feilsått. Og du har gitt ut bøker med titler som for eksempel «Hvis skolen ikke fantes».

– Det siste er jo bare en enkel betraktning om hvordan det er. Jeg synes det er mer forbausende at det ikke er selvlinsende for andre at skolen har en vesentlig oppbevaringsfunksjon i samfunnet, og at den er bygd opp slik at den passer best for over- og mellomklassen. At det er høyst tvisomt å snakke om narkotika når man holder tobakk og alkohol utenfor, og at man burde hindre at unge mennesker dør hvis de er fanget inn i farlige livsformer. Alt dette er jo svært enkelt, og jeg ønsker ikke å skape kontroverser. Men jeg forsøker å si at «det var da rart at man kan gjøre det på den måten», sier han.

– Metadonsaken er en god illustrasjon på dette: Hvis det kom en virus som særlig rammet dem som arbeidet

foran en data-skjerm, da ville samfunnet mobilisert enormt. Når det gjelder folk i sterkt truede livssituasjoner som bruker heroin, vet vi også at noe kan gjøres. Det er påvist at deres dødelighet blir betydelig mindre hvis de får metadon. Og det er en billig investering.

Men langtkomne narkotika-brukere skal nektes stoffet som

kan hjelpe dem, mens ingen ville finne på å nekte de sukkersyke insulin. Dette er en forskjell basert på rendyrket moralisme. Og lege-etisk er det et voldsomt brudd med det tilvante: At legen ikke skal ta hensyn til sin pasient, men til pasientens nabo, for ellers ville det kanskje friste naboen til å begynne med heroin. Når man ser et slikt misforhold, må man jo fortelle om det.

Men Christie sier at han egentlig ikke liker å være i den offentlige debatt:

– Nei, det synes jeg er slitsomt. Jeg synes ikke det er morsomt å være en offentlig person, jeg er nokså sjenert. Men når jeg kommer med ny bok, vil jeg at den skal bli kjent, og kringkastingen er et flott alternativ til det å stå på universitetets kateter.

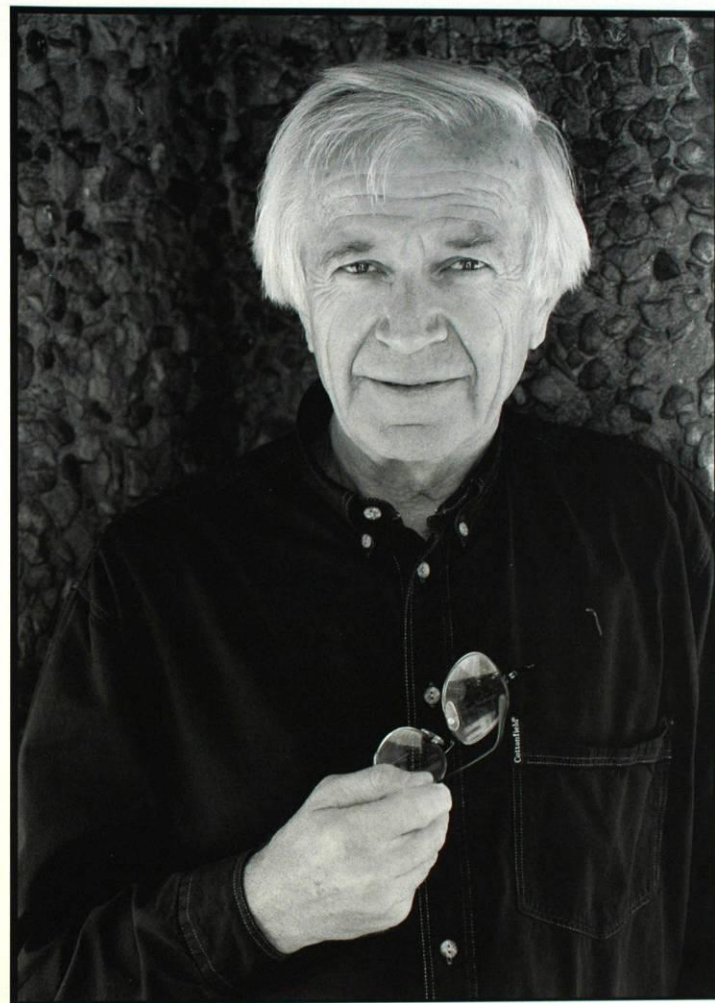
– Føler du at du får gjennomslag for det du sier?

– Jeg tenker av og til som Frelsesarmeen: Synden er der hele tiden. Det er en evig kamp å forsøke å ha et reflektert samfunn.

Jeg vet ikke om det virker eller ei, det ville vært helt latterlig å tenke at det jeg sier,

hadde betydd noe særlig. Vi er så mange, og vi er eksponenter for ting i tiden. Jeg er vel en liten piccoloflytte i det store orkesteret, en som har vært så heldig å ha fått arbeide mange og friske år ved en institusjon som gir rom for å forsøke å utvide forståelsen av grunnleggende fenomener i samfunnet.

portrettet



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