Nikon

CFI60

Optics

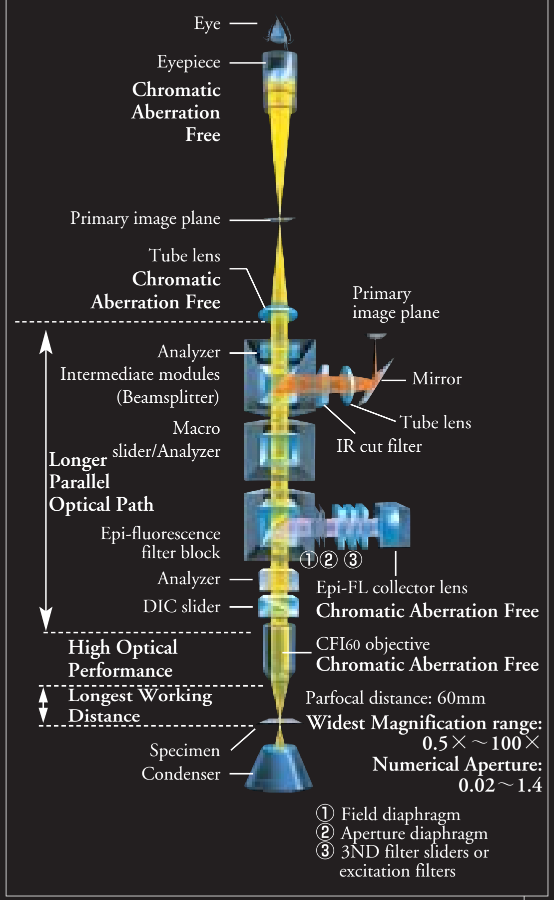
The Ultimate in Optical Performance and System Flexibility

Nikon had two distinct goals in mind when creating its CFI60 optical system for advanced biological research microscopes:

1. To dramatically improve optical performance.
2. To boost overall flexibility of the microscope as a system and increase the performance when various microscope attachments and accessories are used.

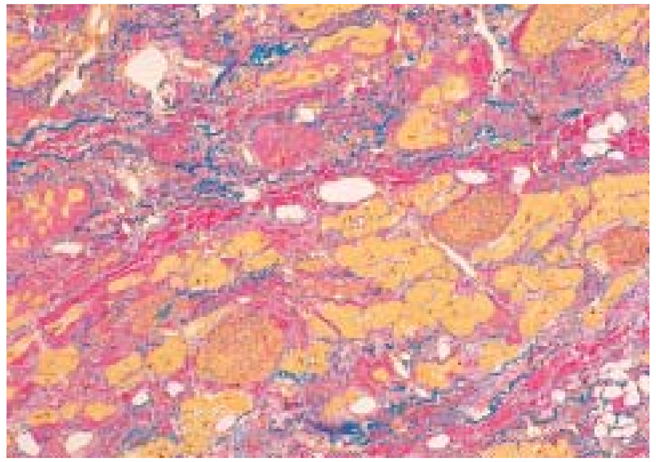
To achieve this end, Nikon had to create a completely new standard for its CFI60 objectives.
By using a tube lens focal length of 200mm and objectives having a parfocal distance of 60mm with a larger diameter by using a thread size of 25mm, Nikon succeeded in realizing both higher N.A. and longer working distances than ever before.
This new optical design solved many related design problems and allowed the creation of 0.5X and 1.0X ultra-low magnification objectives.
In these revolutionary optics, both axial and lateral chromatic aberration have been corrected independently in the objective and the tube lens.
CFI60 objectives are designed to produce flat images without the aid of other components, allowing their use in applications other than microscopy.
The 200mm tube lens creates a smaller angle between light rays passing through the center and those off axis. This minimizes shifts in light rays on the image plane between the center of the field of view and its periphery, dramatically reducing blurring during DIC and epi-fluorescence microscopy.
Nikon also designed the epi-fluorescence system as well as the objectives to curtail auto-fluorescence and flair, contributing to greater contrast during epi-fluorescence observations.
With an array of innovative features, Nikon's CFI60 optical system delivers top-notch performance, enabling their use in increasingly sophisticated biological research.

CFI60 Optical Path
(Conceptual Diagram)



Brightfield and Macro Observation

The most popular observation technique used is brightfield which trans-illuminates a specimen stained with an appropriate coloring reagent, such as H&E (hematoxalin and eosin).



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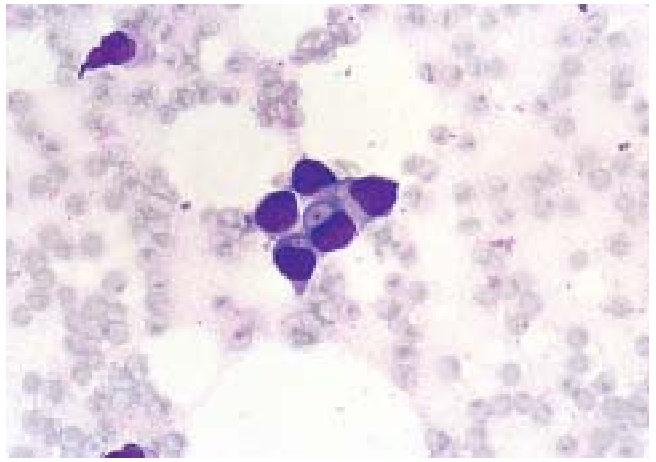

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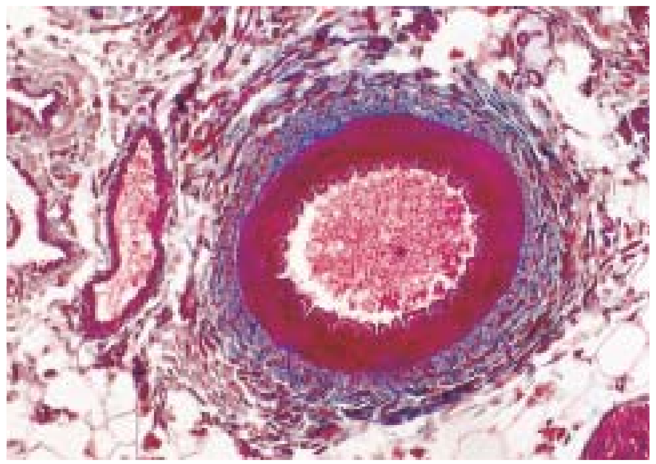

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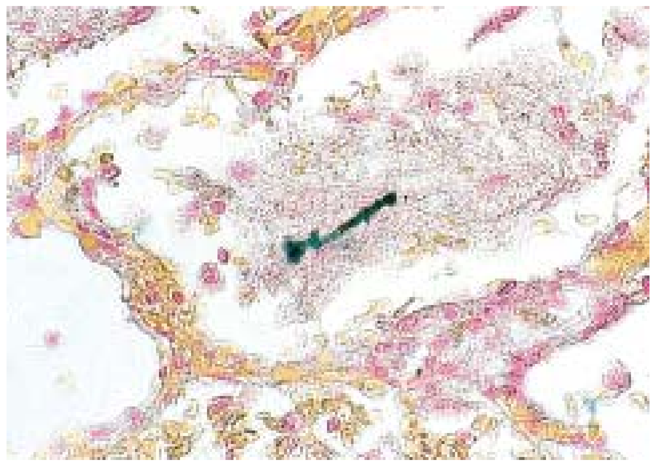

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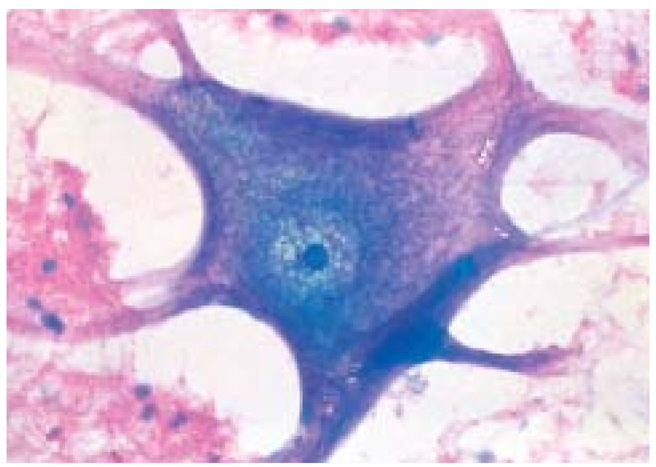

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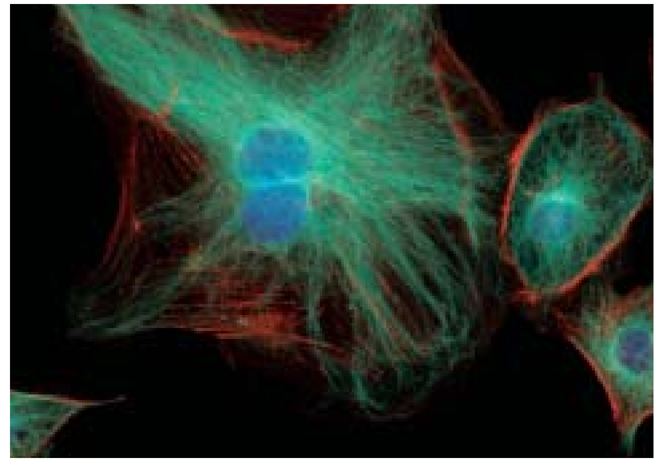
Epi-fluorescence Observation

With the new fluorescence dyes and reagents available, epi-fluorescence has become one of the most useful clinical as well as research techniques in microscopy.
In this technique, excitation light is applied to the specimen stained with specific fluorescent reagents, causing the tagged areas or components of the specimen to emit light.



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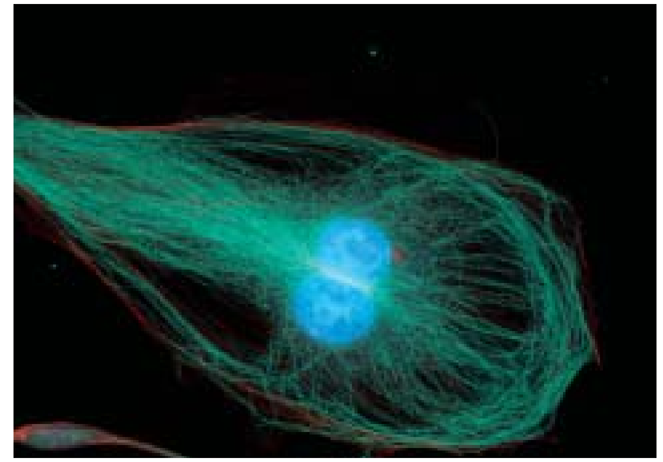

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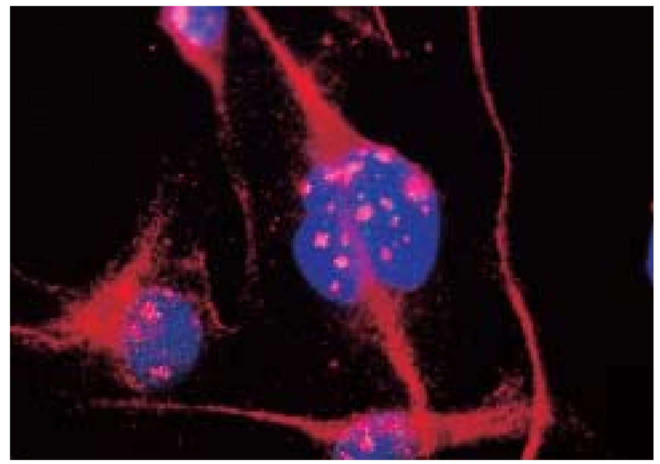

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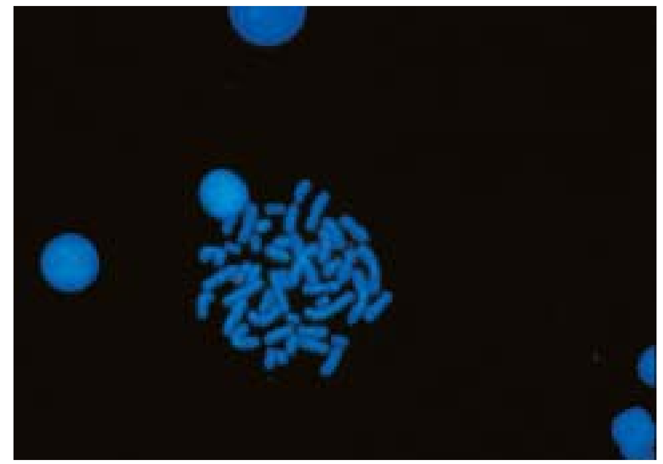

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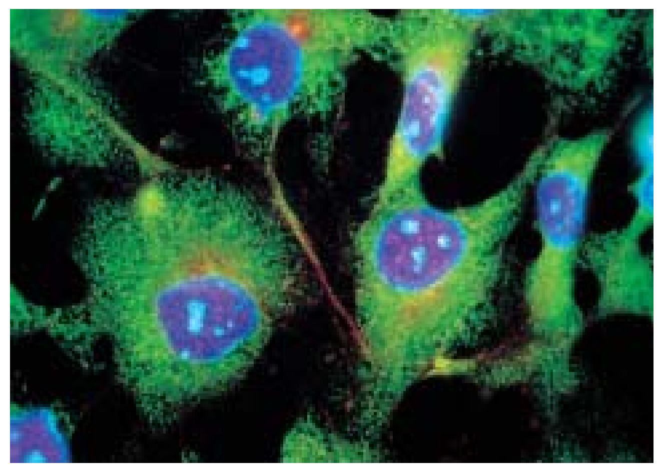

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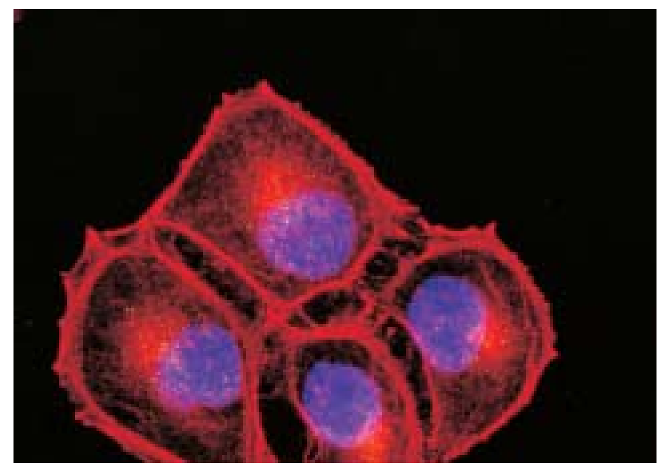

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Nomarski DIC Observation

Used to image the smallest structures in living and unstained specimens, this technique defines the details in 3D-like relief.
The ability of DIC to optically section layer-by-layer through thicker specimens and define structural detail at, or even below, the resolution limit of the optical microscope, makes it the technique of choice for many researchers.


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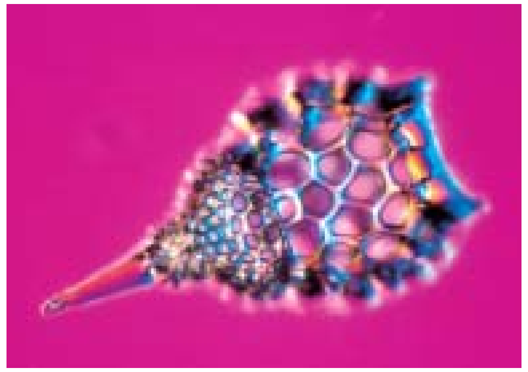
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Phase Contrast Observation

Most living microorganisms or tissues are transparent and colorless, making it difficult to observe their minute structure. The phase contrast observation technique utilizes phase shifts in light rays passing through minute structures to produce image contrast and make them visible. This is the simplest and least expensive method used for unstained specimens.


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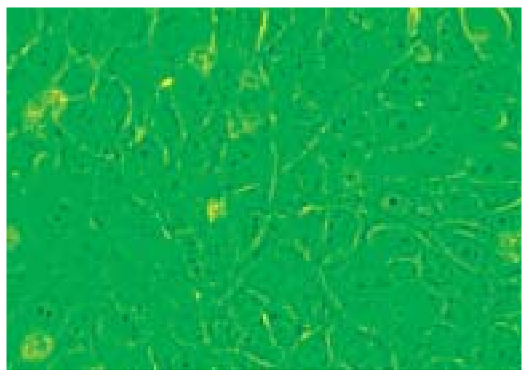
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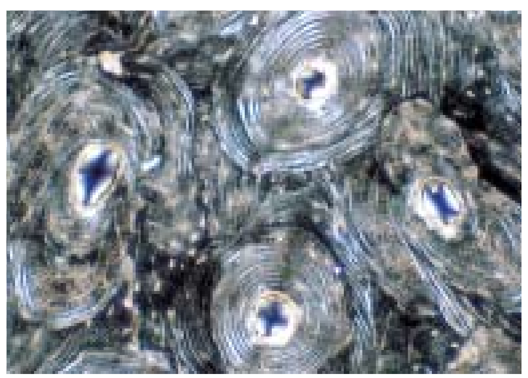
Darkfield Observation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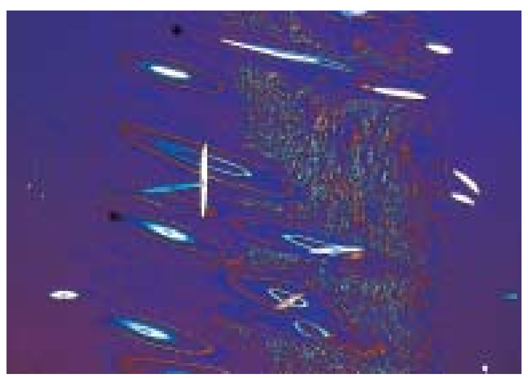
Simple Polarizing Observation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New Series of Objectives Created with Nikon's Accumulated Optical Technologies

1. CFI Plan Apochromat VC Series

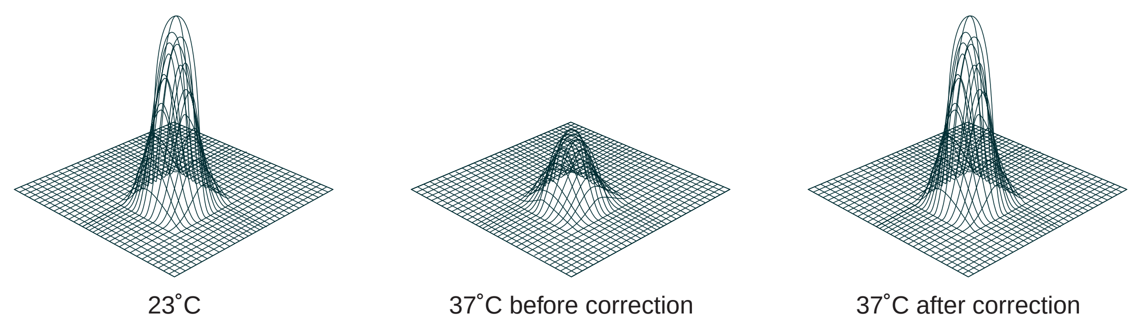
CFI Plan Apochromat VC 60X Oil, N.A. 1.40
CFI Plan Apochromat VC 60X WI, N.A. 1.20
CFI Plan Apochromat VC 100X WI, N.A. 1.40

- Top performance objectives with perfect correction of chromatic aberrations in the visible light range and excellent resolution throughout the view field.
- Perfect choice for multi-stained, fluorescence specimens and when using brightfield and DIC techniques. In addition to the correction range of the conventional Apochromat series (435–660nm), axial chromatic aberration has been corrected up to the violet range (405nm), making these objectives highly effective for confocal applications.
- Observation of images with excellent brightness throughout the view field by minimizing the light loss around the edges—a critical criterion for digital-image capturing.
- The 60X water-immersion type, in particular, features high spectral transmittance, even in the 360nm wavelength range, making it perfect for fluorescence observation of living organisms.

2. CFI Plan Apochromat TIRF Series

CFI Plan Apochromat TIRF 60X Oil, N.A. 1.45
CFI Plan Apochromat TIRF 100X Oil, N.A. 1.45

- Highest N.A. of all Nikon objectives and specifically developed for TIRF (Total Internal Reflection Fluorescence) applications.
- A world-first temperature-change correction ring is included in the 60X oil objective. Users can easily correct temperature-induced changes—from 23°C (room temperature) to 37°C (physiological temperature)—in the refractive index of the immersion oil that can cause spherical aberration.
- The correction ring works perfectly in both DIC and epi-fluorescence microscopy of minute structures. It helps create optimal-quality images by preventing even minute deteriorations in image quality caused by any deviations in coverglass thickness or changes in operating environment, such as temperature fluctuations.



Intensity distribution of dot image

CFI60 Objectives

Description	N.A.	W.D. (mm)	Remarks	
Brightfield				
Achromat flat field				
CFI Achromat 4×	0.10	30.0		
CFI Achromat 10×	0.25	7.0		
CFI Achromat LWD 20×	0.40	3.9		
CFI Achromat 40×	0.65	0.65	Spring loaded	
CFI Achromat LWD 40×C	0.55	2.7-1.7		C.C.0-2
CFI Achromat 60×	0.80	0.3	Spring loaded	
CFI Achromat 100× oil	1.25	0.23	Spring loaded	
CFI Achromat 100× oil, iris	0.5-1.25	0.23	Spring loaded	with iris
Plan Achromat				
CFI Plan Achromat UW 1×	0.04	3.2		
CFI Plan Achromat UW 2×	0.06	7.5		
CFI Plan Achromat 4×	0.10	30.0		
CFI Plan Achromat 10×	0.25	10.5		
CFI Plan Achromat 20×	0.40	1.2		
CFI Plan Achromat 40×	0.65	0.56	Spring loaded	
CFI Plan Achromat 40× NCG	0.65	0.48	Spring loaded	No cover glass
CFI Plan Achromat 50× oil	0.90	0.35	Spring loaded	
CFI Plan Achromat 100× oil	1.25	0.20	Spring loaded	
CFI Plan Achromat 100× NCG	0.90	0.26	Spring loaded	No cover glass
Plan Fluor				
CFI Plan Fluor 4×	0.13	17.1		
CFI Plan Fluor 10×	0.30	16.0		
CFI Plan Fluor 20×	0.50	2.1		
CFI Plan Fluor ELWD 20×C	0.45	8.1-7.0		C.C.0-2
CFI Plan Fluor 20× MI	0.75	Oil 0.35; Glycerin 0.34; Water 0.33	Spring loaded	Multi-immersion; Oil-glycerin-water
CFI Plan Fluor 40×	0.75	0.72	Spring loaded	
CFI Plan Fluor 40× oil	1.30	0.2	Spring loaded	Stopper
CFI Plan Fluor ELWD 40×C	0.60	3.7-2.7		C.C.0-2
CFI Plan Fluor 60×C	0.85	0.3	Spring loaded	C.C.0.11-0.23
CFI Plan Fluor 60× oil, iris	0.5-1.25	0.22	Spring loaded	with iris
CFI Plan Fluor ELWD 60×C	0.70	2.1-1.5		C.C.0.5-1.5
CFI Plan Fluor 100× dry	0.90	0.3	Spring loaded	C.C.0.14-0.2
CFI Plan Fluor 100× oil	1.30	0.2	Spring loaded	Stopper
CFI Plan Fluor 100× oil, iris	0.5-1.3	0.2	Spring loaded	with iris
Plan Apochromat				
CFI Plan Apochromat 2×	0.10	8.5		
CFI Plan Apochromat 4×	0.20	15.7		
CFI Plan Apochromat 10×	0.45	4.0		
CFI Plan Apochromat 20×	0.75	1.0	Spring loaded	
CFI Plan Apochromat 40× C	0.95	0.14	Spring loaded	C.C.0.11-0.23
CFI Plan Apochromat 40× oil	1.00	0.16	Spring loaded	Stopper
CFI Plan Apochromat 60× C	0.95	0.15	Spring loaded	C.C.0.11-0.23
CFI Plan Apochromat 60× oil	1.40	0.21	Spring loaded	Stopper
CFI Plan Apochromat 60× WI	1.20	0.22	Spring loaded	C.C.0.15-0.18; Water-immersion
CFI Plan Apochromat 100× oil	1.40	0.13	Spring loaded	Stopper
CFI Plan Apochromat 100× NCG oil	1.40	0.17	Spring loaded	Stopper; No cover glass
Plan Apochromat VC				
CFI Plan Apochromat VC 60X oil	1.40	0.13	Spring loaded	Stopper
CFI Plan Apochromat VC 60X WI	1.20	0.27	Spring loaded	CC.0.15-0.18; Water-immersion
CFI Plan Apochromat VC 100X oil	1.40	0.13	Spring loaded	Stopper
Plan Apochromat TIRF				
CFI Plan Apochromat TIRF 60X oil	1.45	0.13	Spring loaded	C.C. 0.10-0.22
CFI Plan Apochromat TIRF 100X oil	1.45	0.13	Spring loaded	CG 0.17
S Fluor				
CFI S Fluor 4×	0.20	15.5		
CFI S Fluor 10×	0.50	1.2	Spring loaded	
CFI S Fluor 20×	0.75	1.0	Spring loaded	
CFI S Fluor 40×C	0.90	0.3	Spring loaded	C.C.0.11-0.23
CFI S Fluor 40× oil	1.30	0.22	Spring loaded	
CFI S Fluor 100× oil, iris	0.5-1.30	0.2	Spring loaded	
Water Dipping				
CFI Fluor 10× W	0.30	2.0	Water dipping	
CFI Fluor 20× W	0.50	2.0	Water dipping	
CFI Fluor 40× W	0.80	2.0	Water dipping	
CFI Fluor 60× W	1.00	2.0	Water dipping	

Description	N.A.	W.D. (mm)	Remarks		
Phase Contrast					
Achromat flat field					Phase ring
CFI Achromat DL 10×	0.25	7.0			Ph1
CFI Achromat ADL 10×	0.25	6.2		CG 1.2	Ph1
CFI Achromat LWD DL 20×	0.40	3.9			Ph1
CFI Achromat LWD DL 20×F	0.40	3.1		CG 1.2	Ph1
CFI Achromat LWD ADL 20×F	0.40	3.1		CG 1.2	Ph1
CFI Achromat DL 40×	0.65	0.65	Spring loaded		Ph2
CFI Achromat LWD DL 40×C	0.55	2.7-1.7		C.C.0-2	Ph2
CFI Achromat LWD ADL 40×F	0.55	2.1		CG 1.2	Ph1
CFI Achromat LWD ADL 40×C	0.55	2.7-1.7		C.C.0-2	Ph2
CFI Achromat DL 100× oil	1.25	0.23	Spring loaded		Ph3
Plan Achromat					
CFI Plan Achromat DL 10×	0.25	10.5			Ph1
CFI Plan Achromat DL 20×	0.40	1.2			Ph1
CFI Plan Achromat DL 40×	0.65	0.56	Spring loaded		Ph2
CFI Plan Achromat DL 100× oil	1.25	0.2	Spring loaded		Ph3
Plan Fluor					
CFI Plan Fluor DL 4×	0.13	16.4		CG 1.2	PhL
CFI Plan Fluor DLL 10×	0.30	16.0			Ph1
CFI Plan Fluor DL 10×	0.30	15.2		CG 1.2	Ph1
CFI Plan Fluor DLL 20×	0.50	2.1			Ph1
CFI Plan Fluor ELWD DM 20×C	0.45	8.1-7.0		C.C.0-2	Ph1
CFI Plan Fluor ELWD ADL 20×C	0.45	8.1-7.0		C.C.0-2	Ph1
CFI Plan Fluor DLL 40×	0.75	0.72	Spring loaded		Ph2
CFI Plan Fluor ELWD DM 40×C	0.60	3.7-2.7		C.C.0-2	Ph2
CFI Plan Fluor ELWD ADL 40×C	0.60	3.7-2.7	Spring loaded	C.C.0-2	Ph2
CFI Plan Fluor ELWD DLL 60×C	0.70	2.1-1.5		C.C.0.5-1.5	Ph2
CFI Plan Fluor DLL 100× oil	1.30	0.2	Spring loaded	Stopper	Ph3
Plan Apochromat					
CFI Plan Apochromat DM20×	0.75	1.0	Spring loaded		Ph2
CFI Plan Apochromat DM40×C	0.95	0.14	Spring loaded	C.C.0.11-0.23	Ph2
CFI Plan Apochromat DM40× oil	1.0	0.16	Spring loaded	Stopper	Ph3
CFI Plan Apochromat DM60×C	0.95	0.15	Spring loaded	C.C.0.11-0.23	Ph2
CFI Plan Apochromat DM60× oil	1.40	0.13	Spring loaded	Stopper	Ph3
CFI Plan Apochromat DM100× oil	1.40	0.13	Spring loaded	Stopper	Ph3
Water Dipping					
CFI Fluor DLL 40×W	0.80	2.0	Water dipping		Ph2
Hoffman Modulation Contrast®					
CFI HMC 10×	0.25	6.2		CG 1.2	
CFI HMC LWD 20×F	0.40	3.1		CG 1.2	
CFI HMC LWD 40×C	0.55	2.7-1.7		C.C.0-2	

CG : Cover Glass thickness (mm)
CC : Correction Collar (mm)

Condensers

For Upright Microscopes

Type	N.A.	Magnifications
Achromat swing-out condenser 1-100×	0.8*1/0.12*2	1-100×
Achromat swing-out condenser	0.9*1/0.22*2	2-100×
Achromat/Aplanat condenser	1.4	10-100×
LWD achromat condenser	0.65	4-40×
Low power condenser	0.15	1-4×
Achromat condenser	0.85	4-100×
Abbe condenser	0.9	4-100×

*1 (4–100X) *2 (1–4X)

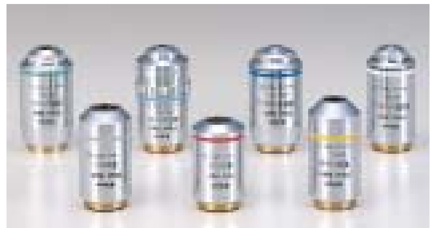
Type	N.A.	Magnifications
Darkfield condenser (dry)	0.8-0.95	10×-40×
Darkfield condenser (oil)	1.2-1.43	20×-100×
Universal condenser (dry)	0.9/0.13	2-100×
Universal condenser (oil)	1.4	20-100×
Phase contrast condenser	0.9	10-100×

For Inverted Microscopes

Type		N.A.	W.D.(mm)	Ph module	HMC module	DIC module	Magnifications
System turret condenser	ELWD system condenser lens	0.3	75	L.1.2		NL	2~60×
	LWD system condenser lens	0.52	30	L.1.2.3	MC1.MC2.MC3	NL.NM.NH	4~100×
Condenser	HMC condenser lens	0.4	44		MC1.MC2.MC3		10~40×
	Dry top lens for high N.A. condenser	0.85	5			NM.NH	10~100×
	Water immersion top lens for high N.A. condenser	0.9	4			NM.NH	10~100×
	Oil immersion top lens for high N.A. condenser	1.4	1.92			NM.NH-SS	10~100×
	ELWD condenser for phase contrast	0.3	75	L.1.2.3			2~20×
	SLWD condenser	0.12	190	L.1			4~40×

CFI60 Objectives

Apodized Phase Contrast Series
Nikon specifically developed this series for phase contrast observations by using its proprietary Apodization process to improve the objective's phase ring. Division activities taking place within a specimen—hitherto often obscured by unwanted halos—can now be observed more clearly.



CFI Plan Apochromat Series
This new CFI Plan Apochromat series features longer working distances with high Numerical Apertures and is designed to correct all optical aberrations throughout the visible spectrum from violet to red from center to edges across the entire 25mm field of view. Superior image flatness and color reproduction, plus resolving power at the theoretical limit of today's optical technology are also featured.

CFI Plan Fluor Series
Featuring an extra-high transmission rate, especially in the ultraviolet wavelength, and flatness of field comparable to the CFI Plan Achromat series, the CFI Plan Fluor series is designed for fluorescence observation and photomicrography. Because of this improvement in quality, these objectives can function as multi-purpose objectives for brightfield, fluorescence, polarizing, and DIC observations.

CFI Plan Achromat Series
Nikon's new CFI Plan Achromat series provides incredible image flatness over the entire 25mm field of view, with chromatic aberration corrected throughout the entire visible spectrum. These objectives are suitable not only for routine laboratory work but for photomicrography.

CFI Achromat Series
Correction for chromatic aberration in this new series has been dramatically improved and is now at the same level as the CFI Plan Achromat Series. These new CFI Achromat objectives were also corrected for spherical aberration and coma and image flatness across the 22mm field of view has been drastically improved.
The result: truly exceptional quality for this class of objectives.

CFI S Fluor Series
This new CFI S Fluor series ensures a high transmission rate of ultraviolet wavelengths down to 340 nm for fluorochromes like indo-1, fura-2, and fluor-3. Also, these objective have improved signal-to-noise ratios (S/N) for short wavelengths and have high N.A., making the fluorescence images they produce significantly sharper and brighter.

CFI Plan Apochromat Series for Phase Contrast
Correction for chromatic aberration has been improved and now extends across the entire visible spectrum to include the violet wavelength. High Numerical Apertures with longer working distances, comprehensive aberration correction, and superior flatness of field of view make Nikon's new CFI Plan Apochromat series for phase contrast ideal for the most demanding research projects. Moreover, these objectives can be used for DIC observation.

CFI Plan Fluor Series for Phase Contrast
These objectives are multi-purpose; they can be used for brightfield, fluorescence, phase contrast, or Nomarski DIC observations. They facilitate high-quality fluorescence observation and provide exceptionally detailed resolution of minute structures in phase contrast or DIC observation. The use of phase contrast to find the desired portion of the specimen before switching to fluorescence observation is an excellent way to minimize fluorescence photo bleaching.

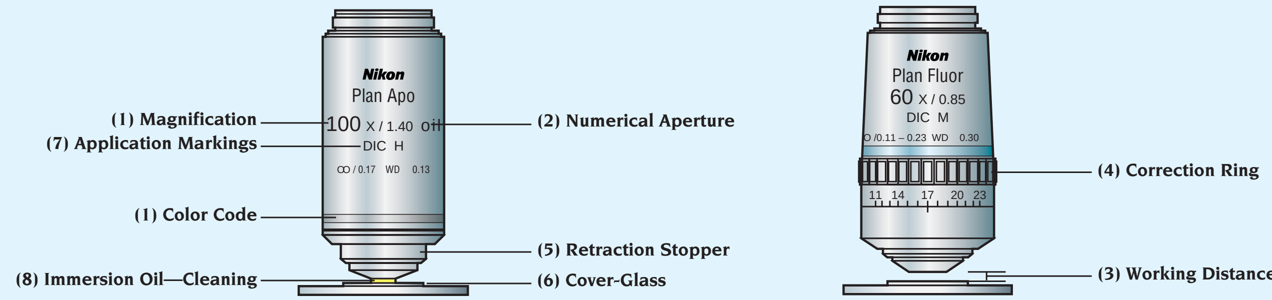
CFI Plan Achromat Series for Phase Contrast
Nikon's new CFI Plan Achromat series provides incredible image flatness over the entire 25mm field of view, with chromatic aberration corrected throughout the entire visible spectrum. With incredible image sharpness, these objectives can be used for routine laboratory work as well as exacting research.

CFI Achromat Series for Phase Contrast
Correction for chromatic aberration in this new series has been dramatically improved and is now at the same level as the CFI Plan Achromat Series. These objectives now boast performance far outstripping their cost.

CFI Plan Fluor ELWD Series for Phase Contrast
Offering superb flatness of field, high UV transmission rates, and high Numerical Apertures with extra long working distances, these objectives are well suited for fluorescence observations, especially with inverted microscopes. Because of their superior optical design, CFI Plan Fluor ELWD DM objectives can be used universally for all other observation techniques, including brightfield, fluorescence, phase contrast, and Nomarski DIC.

Hoffman Modulation Contrast Series
These objectives have been completely redesigned by Nikon, allowing the contrast direction to be changed using a modulator inside the objective. That direction, once set, is maintained over the entire magnification range from 10X to 40X.

Note: Hoffman Modulation Contrast and HMC are registered trademarks of Modulation Optics Inc.



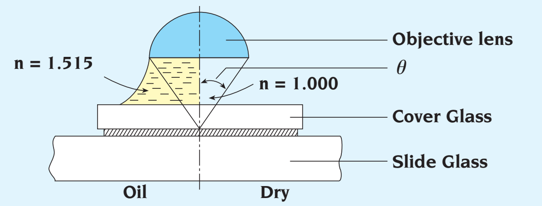
Nikon offers a wide variety of CFI objectives. To assist the user they are clearly marked with information on the objective barrel such as: which DIC module or Phase Ring to use.

(1) Magnification and Color Code
A color coded ring on the barrel identifies the magnification of the objective:

Mag.	1X	2X	4X	10X	20X	40X	50X	60X	100X
Color code	Black	Gray	Red	Yellow	Green	Light Blue	Light Blue	Cobalt Blue	White

Note: Nikon offers the lowest magnification objective commercially available, the Macro 0.5X on the E800M and E1000M microscopes.

(2) Numerical Aperture (N.A.)
N.A. is the most important factor in defining the performance characteristics of an objective.
N. A.= n sin θ
n: the refractive index of the media at d-line (587nm)
For dry objective n=1.000 (air)
For oil objective n=1.515 (oil)
For water objective n= 1.333 (water)
θ :Half angle of incident rays to the top lens of the objective



The higher N.A., the higher resolving power.
When the resolving power is defined as the power to recognize the two points,

$$R= 0.61\frac{\lambda}{N.A.}$$

If λ =0.55 μm (Green light) and N.A.=1.4,
resolving power (R) = $0.61\,\frac{0.55}{1.4} = 0.24\,\mu m$

The higher N.A. the brighter image we take.

$$\text{Brightness: } B \propto \left\{\frac{N.A.}{\text{Total Magnification}}\right\}^2$$

The higher N.A., the shallower the depth of focus (DOF).

$$DOF = \frac{\lambda}{N.A.^2}$$

(3) Working Distance
Working distance (W.D.) defines the distance between the top lens of the objective and the surface of the cover glass.
CFI60 objectives can offer longer working distance with high numerical aperture.

(4) Correction Ring
Dry objectives with high Numerical Aperture are susceptible to spherical and other aberrations which can impair resolution and contrast when used with a cover glass whose thickness differs from the specified value. A 1 1/2 cover glass (0.17mm thick) should be used as standard, however not all 1 1/2 cover glasses are exactly 0.17mm and many specimens have media between them and the cover glass. The correction ring is used to adjust for these subtle differences to ensure the optimum objective performance.

How to use the correction ring
- Position the ring at 0.17. The thickness of the standard cover glass is 0.17mm.
- Focus the lens on a small artifact in the specimen.
- Rotate the ring very slightly and focus the lens again to check if the image has improved or degraded.
- Repeat the above step to determine if the image is improving or degrading in the direction you are turning the ring.
- If the image has degraded, follow the same procedure in the opposite direction to find the position offering optimum resolving power and contrast.

(5) Retraction Stopper
Some objectives for oil immersion have a retraction stopper. In order to prevent clean slides from being accidentally smeared with immersion oil, the retraction assembly can be engaged by pushing in the front element and twisting it to the right. This will lock the objective in the up position so it will not leave immersion oil on a clean slide as the nosepiece is rotated. Twisting to the left will release the retracted objective for use.

(6) Cover-Glass
For optimum performance, the thickness of the cover glass should be 0.17mm. For example, at N.A.=0.95, a 0.01mm difference in thickness reduces image formation by 45% from the ideal image.

N.A.	Difference in cover glass thickness 0.01mm	0.02mm
0.3	100%	100%
0.45	100	100
0.7	98	92
0.85	81	43
0.95	45	29

(7) Application Markings
DIC: for Differential Interference Contrast
DM: Phase contrast, Dark contrast middle type
DL: Phase contrast, Dark contrast light type
DLL: Phase contrast, Lower contrast type

(8) Immersion Oil—cleaning
After using immersion oil, gently blot the lens dry with lens tissue. Then slightly moisten a piece of lens tissue with petroleum benzene (Naphtha) and clean off all traces of the oil from the immersion objective. Cleaning is essential for water immersion objectives as well; after use, wipe the water off the top lens.

Photo samples courtesy of:

1. Heart tumor
   CFI Plan Apochromat 10X
   Dr. Yasuko Tomizawa, Mr. Akira Miyama
   Tokyo Medical Woman`s Collage, Japan

2. Cytological Preparation of
   Tumour Cells showing Cytoplasmic Vacuoles
   CFI Plan Apochromat 60X
   Dr. Andrew M.T. Clarke
   Consultant Histopathologist
   York District Hospital, U.K.

3. Artery
   CFI Plan Apochromat 40X

4. Asbestos body (ferruginous body) in lung adjustment to
   malignant mesothelioma
   CFI Plan Apochromat 60X
   Dr. Andrew M.T. Clarke
   Consultant Histopathologist
   York District Hospital, U.K.

5. Baby Mouse Cross Section
   CFI Macro 0.5X

6. Multi Polar Neuron-Human
   CFI Plan Apochromat 100X oil

7. Mouse
   CFI Plan Apochromat VC 60X oil

8. Mouse
   CFI Plan Apochromat VC 60X oil

9.11.12. (Mycoplasma-infected) Culture of COS cells
   (Green African Monkey cells)
   CFI Plan Apochromat 100X oil
   Dr. Nancy Kedersha, Ph.D.
   Research Associate
   Brigham & Woman`s Hospital, Harverd Medical School
   Dept. of Rheumatology, Immunology & Allergy, U.S.A.

10. Chromosome
   CFI Plan Apochromat 100X oil
   Dr. Fumiharu Yagasaki, M.D.
   First Dept. of Internal Medicine, Saitama Medical School, Japan

13. Zebrafish lung
   CFI Fluor 40X W

14. Radiolaria (single)
   CFI Plan Apochromat 20X
   Dr. Robert Smith
   Formally Cornell Univ., Fellow of Royal Microscopy Society
   Consultant for Smith Kline Lab. & Pharmaceutical Co., U.S.A.

15. Nerve tumor, TGW
   CFI Plan Fluor ELWD 40X DM

17. Monkey Kidney, JTC-12
   CFI Plan Fluor ELWD 40X DM

18. Bone
   CFI Plan Apochromat 20X

19. Mouse Scalp
   CFI Plan Apochromat 4X

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